THE GAS JOURNAL

JUNE 21, 1933

Vol. 202. 85th Year No. 3657

A Glance at the Contents—

Cold Tars.

Prof. Dr. Mallison, of Berlin, gives the specification of the Deutschen Strassenbauverband for two types of cold tar, and makes a comparison with the American cold tar regulations. [p. 862.]

Filled Tars.

We give an abstract of reports by Messieurs P. Le Gavrian, D. Boutet, and G. Bedaux on the subject of filled tars. The reports were presented at the International Road Tar Conference last week. [p. 861.]

Association of Statutory Meter Inspectors.

The Annual General Meeting of the Association of Statutory Inspectors of Gas Meters was held in the County Hall, Westminster Bridge, on June 14, with Councillor J. W. Willoughby, M.B.E., J.P., in the chair. [p. 867.]

International Road Tar Conference.

Sir David Milne-Watson presided at the International Road Tar Conference held at Lucerne last week. He said that, although the tar resources of different nations might vary in nature and amount, many of the problems involved in their more efficient utilization were general. It was to the common advantage that the results of study, experiment, and experiences should be pooled, and it was with this object that the Conference was called. [p. 861.]

Distribution Superintendent Required.

A 600-million undertaking invites applications for the post of Distribution Superintendent, the commencing salary offered being £350 per annum. [p. 878.]

Flow of Gas in Pipes.

Mr. W. E. Benton, Chief Chemist to Cannon Iron Foundries, Ltd., contributes a fascinating article on this subject, advancing theories regarding the nature of viscous and turbulent flow. His arguments are largely based on the kinetic theory. [p. 869.]

Institution Whitsun Cruise.

Favoured by perfect weather, the Institution Whitsun Cruise on the Cunard liner "Lancastria" proved highly successful. An idea of the enjoyment and interest which marked the cruise of 1709 miles will be gained from an article by one of the party. [p. 859.]

Tar Concrete.

In a paper presented at the International Road Tar Conference held in Lucerne Mr. W. E. Cone, Technical Adviser to the British Road Tar Association, discusses the use of a heavy traffic mixture which can be laid as a single coat. This tar concrete is a happy medium in an attempt to obtain maximum values for resistance to displacement and durability. The type of construction he describes will give good service under traffic up to 30,000 tons a day. [p. 864.]

Forthcoming Engagements

June 26.—I.G.E.—Meeting of Gasholder Sub-Committee, 2.30 p.m.

June 28.—I.G.E.—Meeting of Board of Examiners, Oral Examinations.

June 29.—I.G.E.—Meeting of Joint Lighting Committee.

July 4.—I.G.E.—Meetings of Gas Education Committee, 3 p.m.; Consultative Committee, 4.30 p.m.

July 5.—SOUTHERN ASSOCIATION (EASTERN DISTRICT).—Meeting at Redhill, noon. Subject for discussion: "General Installation Charges."

July 10.—I.G.E.—Meetings of Finance Sub-Committee, 2 p.m.; Finance Committee, 2.30 p.m.; Executive Committee of the Council, 3 p.m.; Benevolent Fund Committee of Management, 4.30 p.m.

July 11.—I.G.E.—Meeting of Council, 10 a.m.

July 12.—I.G.E.—Meeting of General Research Committee, 10 a.m.

July 21.—MANCHESTER DISTRICT ASSOCIATION.—Visit to the Higginshaw Gas-Works, Oldham. Paper by Mr. Norman Hudson, Mirfield—"Observations on the Differential Charges of Gas for Distribution Purposes."

July 24.—I.G.E.—Meeting of Liquor Effluents and Ammonia Sub-Committee.

July 25.—I.G.E.—Meetings of Joint Research Committee, 10.30 a.m.; General Research Committee, 2.30 p.m.

Sept. 7.—NORTH BRITISH ASSOCIATION.—Annual Meeting in Paisley.

Nov. 7-8.—I.G.E.—Autumn Research Meeting.

EDITORIAL NOTES

His Majesty's Appeal to the Economic Conference

NEARLY one thousand people were present in the Geological Museum, South Kensington, on Monday afternoon of last week, to witness the opening by His Majesty of the World Monetary and Economic Conference, the invitations to which included the representatives of 66 nations. Such a conference, conducted in the broadest spirit, must result in immeasurable benefit to mankind; in the absence of whole-hearted co-operation, the outcome may well prove disastrous. His Majesty is hopeful of the outcome, and may not we, his subjects, derive hope from his hope?

> I fully recognize the magnitude of the task of this Conference, but there is evidence of a real desire to reach agreement which gives me hope. All nations are suffering from a common ill. This is shown only too clearly by the rise in the figures of unemployment. The meaning of these figures in terms of human suffering has been my constant concern in recent years, as it has been the concern of every one of you here to-day upon whom the responsibility of Government has rested.
>
> In the face of a crisis which all realize and acknowledge, I appeal to you all to co-operate for the sake of the ultimate good of the whole world.
>
> It cannot be beyond the power of man so to use the vast resources of the world as to ensure the material progress of civilization. No diminution in those resources has taken place. On the contrary, discovery, invention, and organization have multiplied their possibilities to such an extent that abundance of production has itself created new problems. And together with this amazing material progress, there has come a new recognition of the interdependence of nations and of the value of collaboration between them. Now is the opportunity to harness this new consciousness of common interests to the service of mankind.
>
> HIS MAJESTY THE KING.

Tar Concrete

IN a paper presented at the International Road Tar Conference held in Lucerne last week, Mr. W. E. Cone, Technical Adviser to the British Road Tar Association, dealt with the properties and method of application of a tar concrete which will give good service under traffic up to 30,000 tons a day. The contribution is an important one, and it is published in full in to-day's "JOURNAL." It shows how necessary it is to have a knowledge of the manner in which tar and soft pitch function as binders in varying aggregate mixtures, and it also shows how far we have travelled towards producing a road which will withstand modern traffic conditions in all kinds of weather, as distinct from merely producing a road tar. The B.R.T.A. have done splendid work in popularizing gas-works tar.

A good road must have stability, durability, and safety under all conditions; and Mr. Cone puts forward his specification for a heavy traffic mixture which can be laid as a single coat on any well-drained and strong foundation. He points out that the principal weakness of fine aggregate tar concrete compressed mixtures lies in their incapacity to maintain the requisite degree of structural strength necessary to prevent distortion and rutting of the pavement taking place under the combined influence of high sun temperatures and heavy traffic. He does not suggest that a mixture cannot be designed to overcome the disabilities, but rather that it can only be done at the expense of the brittleness of the pavement under lowered temperature conditions, which leads to cracking in the surface. The introduction of a substantial proportion of coarse aggregate in the mixture is of value in increasing the structural strength of the pavement, with less liability for cracking to take place, and it also ensures a safe surface. Fine aggregate tar concrete mixtures are less serviceable for heavily trafficked roads than are the coarse and fine aggregate mixtures.

The author maintains that there is no justification for the employment of more than one mixture. The weakness of two-coat tar concrete, or, in fact, any other similar type of bituminous work, is that the method of construction must result in inequalities in the resultant structure, due to the difficulty of obtaining a perfect bond between two structures of dissimilar characteristics. Also, apart from the elimination of the disabilities referred to by the employment of a single mixture, considerable economies can be effected by its adoption. Mr. Cone's tar-concrete consists of mineral aggregate, mineral filler, and soft pitch; and the paper gives full instructions on how to apply this mixture to the road.

We also publish to-day the contribution by Prof. Dr. Mallison, of Berlin, to the Conference. This deals with cold tars—*i.e.*, tars which, by the addition of a volatile solvent, can be laid on the street in liquid form at the normal temperature. The author gives the specifications of the Deutschen Strassenbauverband for two types of cold tar, and contrasts these with the American regulations. We give an abstract, too, of reports by Messieurs P. Le Gavrian, D. Boutet, and G. Bedaux on filled tars.

Viscous and Turbulent Flow

THOSE readers who are scientifically minded will thoroughly enjoy Mr. W. E. Benton's fascinating suggestions as to what happens when gas flows along a pipe—the nature of viscous and turbulent flow. The conscience of the author is by no means dormant—it is a conscience which demands a reason why certain mathematical expressions should allow of the calculation with some accuracy of the resistance to flow offered by a pipe of almost any size and shape. While many work happily with the machinery of empirical equations, Mr. Benton needs a picture of what happens, a theoretical basis, before "trusting to the working of an algebraical 'mill.'" He has a very pleasant method of scientific attack, and a commendably clear style in expressing his thoughts. Without making any attempt to add useful constructive criticism of his views, it may serve a good purpose if we endeavour to epitomize his findings.

Mr. Benton first discusses streamline flow, in which every particle of a fluid pursues a smooth undeviating path parallel to the axis of the pipe, the orderliness of this flow being "one of the very rare instances of Nature behaving in a perfectly simple manner." Calling to his aid the kinetic theory, he interprets the viscosity of a fluid as a property arising from interchange of molecular momentum, somewhat similar to the effect of throwing bricks from a fast goods train into the trucks of one moving more slowly *in the same direction*. When flowing through a pipe in this manner the gas may be assumed to travel in a series of thin co-axial sleeves, the outermost

being actually stationary, and the greatest velocity being in the centre. Each imaginary sleeve is always losing momentum to its outer neighbour and gaining momentum from those inside. Since no sleeve, on balance, either gains or loses momentum, any instantaneous loss in momentum, due to the sleeve losing more than it receives, must be immediately made good from its potential energy. Thus the pressure difference acting between the ends of the sleeve represents the net rate of loss in molecular interchange of momentum. Arguing in this manner he arrives at Poiseuille's formula for viscous flow.

Passing to turbulent flow, he asks why, in considering turbulent flow, engineers regard kinetic energy per unit volume ($\frac{1}{2}\rho v^2$) as being of more significance than the rate of flow of momentum per unit area (ρv^2), when the latter is so helpful in an attempt to explain the meaning of turbulent flow, and does not interfere with accepted formulæ for determining flow. Passing through an interpretation of Reynold's Parameter—that peculiar quantity of such immense importance in the study of fluids—Mr. Benton arrives at the conclusion that turbulent flow is due to the formation at a critical point—when a hypothetical couple becomes a real one—of small rotating bodies of gas near the walls of the pipe. These eddies, he suggests, will have an immediate tendency to move towards the axis of the pipe. The eddy will have no initial radial velocity, and will be subject only to a radial acceleration. It will move at first tangentially to the pipe wall and then gradually towards the centre as its velocity down the pipe increases. These tiny eddies will be formed at very many points on the pipe surface, possibly according to some logical arrangement of which we have no knowledge. Since a number of eddies may be formed at the circumference of the same cross-section of pipe, their paths will sweep out an envelope or shell, before they intersect at the centre-line. This shell—it has no real existence, but is purely an envelope of eddy paths—will have a certain thickness, depending on the size of the eddy, and Mr. Benton assumes that the eddy does not grow in size, and that therefore the imaginary shell is of uniform thickness. At any point on the shell the eddy will have the same forward velocity as that of the fluid about it. "The fluid in the shell is therefore the actual fluid whose momentum is interfered with by the formation of these eddies at the strip of surface on the wall where the shell makes contact." From this conception of eddy shells, Mr. Benton works out the interesting conclusion that the coefficient of friction in turbulent flow is possibly the ratio of the fraction of momentum lost in the formation of the eddy to the "expansion" of the eddy shell.

The Industrial Position

It seems to become increasingly difficult to form any balanced opinion as to the national or international position from day to day. While there is naturally the keenest desire on the part of everyone to find tangible evidence of improvement in industrial affairs, and to recognize signs of still better things to come, the point has ever to be borne in mind that exaggerated optimism has dangers no less real than those of undue pessimism. An instance of this was cited lately by the writer of a letter in the *World's Press News*, who said that, spurred on by news of a trade boom in Britain—probably the result of some enthusiastic reporter's visit to an industrial area—several families in a sound position in the Dominions, but not earning pre-war salaries, had given up their security, sold house and home, and returned to Britain, where they honestly believed trade had revived and high wages once more could be obtained. As may be imagined, the results have been disastrous. Appealing to editors and reporters for an undistorted perspective, the writer of the letter in question remarks that "people in this country have learned to read between the lines." If such a method of reading is necessary, it is much to be regretted.

But without any risk of misleading, there are encouraging facts which can be placed on record. There was a rise in British exports in May as compared both with the preceding month and with May of last year. It is true that imports also increased, and that the month's visible adverse balance was somewhat greater than in either of the two comparable periods, but for the five months' trading of this year the excess of imports over exports is over £20,000,000 less than for the corresponding period of last year. Exports of raw materials in May rose by 17% over the same month of 1932, and there is also an improvement shown in the matter of manufactured articles. Coal exports were 1% greater than in the same month of 1932, and were the largest since October, 1931; while as compared with April iron and steel exports advanced by £595,000, or 28%. These figures are taken from the *Financial Times*, who, in the same issue, made the statement that, "in order to deal with the big volume of orders on the books, the management of Steel, Peech, & Tozer, Rotherham, one of the organizations in the United Steel Companies group, has had to institute a 24-hour working day in the form of three shifts a day, each of eight hours. It is many years since the state of the order books necessitated such a course. The much improved position is mainly due to the check upon imports of Continental steel materials imposed by the application of import duties."

The same subject is dealt with by the *Investors' Chronicle* in an article which goes to show that business is improving steadily, and has been doing so for some months. It is stated therein that one has to go back to the period just after the real slump had begun in 1930 to find higher figures, and as stocks of steel products are now very low in this country there is hope that outputs at or near the present level may continue. Other indications of the improvement are to be found in such miscellaneous confirmatory details as the reappearance of forward inquiry and forward ordering after months of hand-to-mouth business; the greater activity in scrap metal; and the larger net imports of iron ore, which for the first five months of 1933 have been 1,070,301 tons, against 805,452 tons in the same period of 1932, and 973,341 tons in the same period of 1931.

Pig-iron output, which has lagged behind steel owing to the consumption of pig-iron stocks, was better with 339,900 tons for the month of May, against 324,700 tons in April and 332,200 tons in March.

PERSONAL

RETIREMENT OF MR. HUBERT POOLEY.

"It would be impossible for any public official to give more loyal service to any authority than has been given to the Leicester Corporation by Mr. Pooley." This tribute was paid to Mr. Hubert Pooley, M.Inst.C.E., the retiring Engineer and Manager of the Leicester Gas Undertaking, by Alderman H. Carver, Chairman of the Gas Committee, at a complimentary supper at the Town Hall, given to Mr. Pooley on his retirement from the service of the Corporation after more than 20 years' work in charge of the Department.

Alderman Carver said Mr. Pooley's heart was always in his work. He had set a wonderful example to his staff.

Tributes to Mr. Pooley were also paid by the Town Clerk on behalf of the officials, by Alderman E. Grimsley, Vice-Chairman of the Committee, by Mr. G. E. Hilton, the former Chairman of the Committee, and by the Lord Mayor.

The Town Clerk in his speech said many of them must feel in parting with Mr. Pooley that an Act of Parliament which said a man was too old at 65 was a mistake.

Alderman Grimsley remarked that one of the greatest of Mr. Pooley's qualifications was the fearless manner in which he gave his advice to the Committee throughout his years of service with the Leicester Corporation.

Alderman W. K. Billings in his tribute said few people in Leicester were aware of the great work Mr. Pooley did during the war.

Alderman Carver handed to Mr. Pooley an illuminated address.

In his reply, Mr. Pooley said that his first works were at Dunfermline, where he spent seven years in the service of Corporation and Company, after which he was Engineer and Manager of the Gas and Electricity Works at Stafford for ten years, going to Leicester in 1910. Careful records had been kept which showed that since 1910 the savings made in the production of gas at Leicester have been over £1,750,000, the average for the last five years being £116,240. The complete new works recently built at Aylestone Road cost, including the gasholder, £262,235, and

were one of the most up-to-date units in the country. The works were most economically built, costing £220 per million. He was satisfied that, in spite of many difficulties, and in spite of the fact that coal and labour still cost more than 100% above the costs of 1910 to 1913, they had been able to sell gas at an advance of less than 56% of the stabilized prices of gas before the war.

Members of the staff and employees of the Gas Department gathered on Tuesday last to present Mr. Pooley with a solid silver tray and hot water jug, to complete an existing set, a McMichael 4-valve portable wireless set, and a mercury column barometer.

The tray was inscribed as follows:

Presented to
HUBERT POOLEY, Esq., M.Inst.C.E., M.Inst Gas E.,
Engineer and Manager of the
City of Leicester Gas Department,
Oct. 1, 1910, to June 13, 1933,
by the Staff and Workmen at the
Central Offices, Aylestone Road Works, and Belgrave Gate Works,
with their sincere good wishes
on the occasion of his retirement.

The presentation was made on behalf of the staff and employees by Mr. G. Bernard Fiddes, Assistant Engineer, and he was supported by Mr. H. Lythall, Accountant, Mr. R. D. Bentley, Secretary, Mr. W. Bray, representing the employees at Aylestone Road Works, and Mr. R. Halford, those at Belgrave Gate Works. The speakers, who included Mr. W. S. Lovell, formerly Assistant Manager and Chief Cashier, paid high tribute to the selfless devotion and high ideals of Mr. Pooley, also to the affection and esteem in which he was held by all those who had worked under him; and both he and Mrs. Pooley were asked to accept sincere and heartfelt wishes for a bright and happy future from all in the Department.

Mr. Pooley said that he was proud of the Works, of his service, and of the fact that he had been the instrument in making of a large body of staff and employees a happy family. The works when he came were in excellent condition, but it fell to his lot to re-model the whole on modern lines throughout a period of unparalleled difficulty. Mr. Pooley referred to the social activities of the Department, both past and present, and regretted that some of the older amenities had lapsed. He recalled to mind those who had gone, and who had given of their best in the service of the Department. He said that his thoughts particularly went out to Mr. C. S. Robinson, who was Engineer and Manager at Leicester over fifty years ago, and who had so kindly sent his good wishes to him that evening on his retirement. He was deeply touched at the kind thought expressed in the gifts which had been made to him. He thanked the assembly for the wonderful send-off they had given him and for the loyalty which had been shown to him in the past. He asked them all to give to his successor, Mr. James Mitchell, the same devoted service and wholehearted support that they had extended to him.

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Sir Thomas Royden, Bart., C.H., has been elected Deputy-Chairman of the Imperial Continental Gas Association, and Mr. F. H. James, formerly General Manager and Director, has been appointed Managing Director of the Association.

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There will be widespread pleasure in the knowledge that Mr. W. E. Price, Hon. Secretary of the Institution of Gas Engineers, who recently underwent an operation for appendicitis, continues to make very satisfactory progress.

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On Wednesday last Sir Albert Ball, Chairman of the Nottingham Gas Committee, was married to Miss Estelle Dannah, of Cheveney Manor, Quorn.

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His many friends in the Gas Industry will extend their sympathy to Mr. J. S. Burgoyne, of Messrs. W. Parkinson & Co., whose wife died suddenly last week.

THE NEWS OF THE WEEK

Gas Will Figure Prominently in Folkestone's scheme for decorative lighting of the town during the summer.

The Film "Tar" is to be shown on June 26-28 at the Victory Cinema, Dalry, and the Assembly Rooms, Girvan, while on July 13-15 it will be shown at the Alhambra, Monifieth. The film "The Highway" is excellently booked throughout the country.

Purifier Dimensions and Capacities.—It has been pointed out that in Mr. J. H. Duxbury's letter on this subject in last week's issue on p. 802, ten lines from the foot of the right-hand column, the word "plant" was inadvertently omitted after the first word in the line, "purifying."

At the Sixth Plenary Meeting of the International Conference of Benzole Producers held at Lucerne on June 12 and 13, at which most of the countries of Europe were represented, the retiring President, Sir David Milne-Watson, LL.D., D.L., was unanimously re-elected. A general survey of the economic situation of the benzole market in various countries was presented, and technical matters relating to the production, refining, and distribution of benzole were considered. Special attention was paid to the papers concerning the anti-knock value of benzole, and the inhibitor process.

The 16th Annual Gas Cookery Competition for school girls, organized by the York Gas Company, took place at the Gas Company's showrooms, when there was an entry of 17 girls, from 12 to 14 years of age. The test dishes were sausage and "Queen of Puddings." Miss F. Nicholson, Superintendent of domestic subjects education at Leeds, was the judge. The Lady Mayoress of York, Mrs. H. Bloor (wife of the Engineer and Manager to the Gas Company), and other well-known local ladies were present at the competition.

Whessoe Foundry and Engineering Company, Ltd.—The Directors of this Company have decided to pay a dividend of 5%, less tax, in respect of the year ended March 31, 1933, which compares with 7½% for the previous year, 10% for 1930-31, and 17½% for each of the years 1928-29 and 1929-30.

An Ambitious Scheme of summer illuminations has been adopted by the Plymouth Hoe and Parks Committee. The floodlighting of Devonport Park and Mount Wise swimming baths will be effected by gas. The Committee has adopted this illuminant, it is understood, because the cost is less than the estimate received from the City Electricity Department. The illuminations will be carried out by the Municipal Gas Undertaking under the direction of the Engineer, Mr. F. Blackburn.

At a Recent Auction Sale at Barnstaple 100 "B" shares in the Barnstaple Gas Company were disposed of in twelve minutes. The shares were of the nominal amount of £10 each, ranking for a standard of 7%, subject to sliding scale equally with existing shares in the Company of this class. The dividend on this class of share in the Company for the past year was at the rate of £9 2s.%. The prices were as follow: Twenty at £21 per £10 share, 52 at £20, five at £19 15s., ten at £19 10s., and 13 at £19 5s.

James Keith & Blackman Company, Ltd.—The forty-third annual report shows that the amount of business done by the Company during the year exceeded that of the previous year. After providing for payment of preference dividend, and making sufficient allowance for depreciation and reserves against doubtful debts, the audited accounts show an available balance standing at the credit of the profit and loss account of £23,255. The Directors recommend that this sum be appropriated as follows: In declaring a dividend on the ordinary shares at the rate of 8%, less income-tax (absorbing £12,000), and in carrying forward to the current year £11,255.

XUM

South-Eastern Gas Corporation.

Offer to Purchase Sheppy Stock.

The South-Eastern Gas Corporation announces that it has made an offer to stockholders of the Sheppy Gas Company to purchase the whole of the issued consolidated ordinary stock and 6% preference stock on the following terms:

For each £100 consolidated ordinary stock of the Company, either £107 in cash or 85 £1 ordinary fully-paid shares of the Corporation.

For each £100 6% preference stock, either £120 in cash or 110 £1 redeemable 4½% cumulative preference fully-paid of the Corporation.

The offer is open until June 30 and is conditional on acceptance by holders of not less than 55% of issued consolidated ordinary stock of the Sheppy Company.

Sheppy Gas Company has a paid-up capital of £82,203.

Cornish Gas Association.

At a recent meeting of the Cornish Association of Gas Managers it was decided to alter the name of the Association to the "Cornish Gas Association," and Rules and Constitutions were approved which will permit of other gas officials in Cornwall becoming members.

A paper was contributed by Mr. R. J. Williams, Engineer to the Truro Gas Company, entitled "Dri-gas," and a discussion followed.

The question of the re-valuation of gas-works for assessment was discussed and a decision arrived at as to future course of action.

Gas Equipment for Cafés and Hotels.

A Fine Co-operative Sales Effort.

Messrs. Still & Sons, the manufacturers of café and hotel equipment, in conjunction with the Southampton Gaslight and Coke Company, have just concluded a very successful sales campaign for their gas-operated models.

An attractive and compelling window display featuring a model still room served as a focal point for public attention, while inside the Gas Showrooms a demonstration café set was constantly in operation, to the great interest of visitors, and, more particularly, to the many prospects who had been previously circularized.

Mr. F. J. Patching, Messrs. Still's representative, was in charge of the campaign and concluded some highly satisfactory sales, in addition to breaking much new ground and causing local café and hotel proprietors to become "gas minded."

Mr. Patching also gave, on one evening, an instructive lecture to about 80 members of the Company's sales and fittings staffs, in which he covered all points concerning the working, fixing, and maintenance of the appliances.

Third Congress and Exhibition of Industrial Heating.

The third of these quinquennial conferences which were inaugurated in 1923 and are held under the auspices of the Ministry of Public Works will take place in Paris from Oct. 9 to 15 at the Conservatoire National des Arts et Métiers. With it will be associated an exhibition in the Parc des Expositions de la Ville de Paris, open from Oct. 7 to 22.

The Hon. President of the Conference will be M. Henry le Chatelier and the Executive President M. Walckenaer, Inspector General of Mines.

M. P. Couturaud, 5 Rue Michel-Ange, Paris XVI., is the Secretary, and to him all communications should be addressed.

The minimum subscription for individual members is 50 francs and for firms 500 francs.

The programme of the Conference falls into six groups each having its own Chairman and Secretary:

(1) General scientific questions.
(2) Fuel preparation and treatment.
(3) Production and use of steam.
(4) Furnaces, &c.
(5) Use of fuels in internal combustion engines.
(6) Economic questions.

The Transactions of the Conference will in due course be published by *Chaleur et Industrie*.

THE NEWS—continued.

Conversazione of the Institution of Civil Engineers.

On Wednesday evening, June 14, guests numbering 2500 were present at the Conversazione of the Institution of Civil Engineers in Great George Street, Westminster. They were received in the Great Hall by the President, Sir Murdoch Macdonald, K.C.M.G., M.P., and Lady Macdonald, assisted by Brig.-Gen. Sir Henry Maybury, K.C.M.G., and his daughter, Miss Maybury. Sir Henry's election as President of the Institution of Civil Engineers for the year 1933-34 has recently been announced.

Among the guests were Mr. Frank P. Tarratt, President of the Institution of Gas Engineers, and Mrs. Tarratt.

An exhibition of engineering models, scientific apparatus, &c., was staged in the Library, Upper Committee Room, and Museum. A lecture was given by Mr. B. N. Wallis, B.Sc., on "Airships;" one on "Salving the 'Egypt's' Gold" by Mr. J. Swinburne, F.R.S.; and one by Mr. J. C. Wrighton on "Automatic Traffic Signals." Music was provided by the Band of H.M. Royal Regiment of Artillery.

"Mr. Therm"—Publicity.

This is a photograph of a lorry which was entered by the Watford and St. Albans Gas Company in a Carnival Fête at St. Albans in aid of the St. Albans and Mid-Herts Hospital on Whit Monday. There was a large number of exhibits in the Carnival Procession, and the lorry attracted a great deal of attention and was awarded 1st Prize.

How Gas Mantles are Made.

The manufacture of gas mantles is at once a highly intricate and fascinating process; and on Wednesday last, thanks to the hospitality of Messrs. Falk, Stadelmann, & Co., Ltd., members of the Kent Area Salesmen's Circle were afforded the opportunity of inspecting the firm's factory in Wandsworth and of appreciating to what a fine art the firm has developed mantle-making.

The "Veritas" factory, which occupies an area of 6¾ acres, was taken over by Falk, Stadelmann in 1919, and constitutes, perhaps, one of the largest works of its kind in the country. Designed for an annual output of more than 20 million gas mantles, the works, which have recently been re-modelled and re-constructed, possess the most up-to-date machinery and employ some 500 workpeople, for whose comfort everything possible has been done.

To ensure that the high standard of quality found in "Veritas" mantles is always maintained, samples of the work passing through the factory are taken at regular intervals, and submitted to drastic tests as regards their behaviour both under vibration and on the burner. Should any samples prove to be defective, search is at once made for the cause of the trouble, so that it may at once be remedied. If any such samples show a bad result on testing, the batch from which they are taken is not sent out.

The factory is well equipped with up-to-date and extensive plant for printing and box-making.

Prior to the tour of inspection, which was excellently organized, the visitors were entertained at lunch. Mr. Max Falk, Chairman of the Company, presided, and was

THE NEWS—*continued.*

supported by Mr. Hugo Falk and senior officers of the works.

In a happy speech of welcome, the CHAIRMAN, having referred to the mutual benefit which accrued from such visits, said how proud those present must be to assist in the progress of the Gas Industry—a go-ahead public utility and a national asset. In showroom work particularly the past twenty-five years had seen enormous development; appliances were now displayed attractively, and the showrooms were staffed by men who could educate the man-in-the-street on the advantages of gas usage. Turning to the progress of Falk, Stadelmann, & Co., the Chairman explained that quite recently the "Veritas" factory had been re-modelled; and the firm, always staunch believers in the principle that the workers should enjoy comfortable conditions, had provided light and airy rooms and healthy conditions. His Company had served the Gas Industry for the last half-century; and he could truly say that, since its establishment in 1882, the firm's progress had been amazing. To-day, as ever, the Company was on the alert to discover and develop new apparatus to help the Gas Industry, whose co-operation he naturally sought.

Response to the welcome was made on behalf of the Circle by its Chairman, Mr. E. H. DUNN, of the Deal and Walmer Gas Company, who expressed gratitude to the firm for the great hospitality shown.

Following the inspection, tea was served, and the thanks of the Circle to the guides, who had been so helpful in explanation, were voiced by Mr. G. F. DONALDSON, of Tunbridge Wells, and Mr. W. J. A. PICKERING, of Gravesend.

The party were then conveyed to "Veritas House," Farringdon Road, E.C. 1, and inspected the excellently equipped and extensive showrooms of Messrs. Falk, Stadelmann, where gas appliances of all types are shown to the best advantage.

Southampton Gas Workers' Gift to Hospital.

In the presence of a representative gathering at the Royal South Hants and Southampton Hospital on June 13, Sir Russell Bencraft, J.P., Chairman of the Southampton Gaslight and Coke Company, unveiled a tablet commemorating the gift to the Hospital by the employees of the Company of four balconies, which were erected out of a donation of £1000 to the Hospital by the workmen.

High tribute to the employees for their generous gift was paid by the Mayor (Councillor F. Woolley, J.P.), who presided, and other speakers, and the hope was expressed that other firms in the town would follow the example so well set by the Gas Company employees.

Those attending were welcomed by the Chairman of the Hospital, Brigadier-General J. Byron, C.B., C.M.G., and the ceremony took place in the Lower Bullar Ward balcony. Among those present were the Mayoress, Sir Russell Bencraft and Lady Bencraft, Colonel Sir Edwin Perkins, C.B.E. (Deputy-Chairman), Mr. R. C. S. Pearce, Mr. A. W. Oke, and Brigadier E. M. Jack, C.B., C.M.G., D.S.O. (Directors of the Gas Company), Mr. S. E. Whitehead (Engineer and General Manager), Mr. H. Runham (Secretary), Messrs. E. Dunbar (Assistant Engineer), J. Lucas (Distributing and Sales Superintendent), and F. H. Pitman (Chief of Staff), and representatives of various departments of the Company.

The Mayor said it was a fine thing indeed that institutions of mercy and healing received bequests from possessors of wealth, but when a gift came from those who were dependent upon their weekly earnings for their daily bread, and it was given in a spirit of real sacrifice, then the gift was doubly valuable. It was a gift of that character they were present that day to accept, and the Mayor expressed a deep appreciation of what had been done by the employees of the Gas Company.

Sir Russell Bencraft referred to two kinds of benefits that the hospital received—money, which was very difficult to obtain in these days, and service such as that rendered by General Byron and the Committee. Some years ago one of the best Chairmen the Hospital ever had—Sir Edwin Perkins—had made it his business to go round and speak to large firms in the town with a view of getting funds for the institution. He had started what was now called the Workmen's Fund, and out of £35,000 contributed to the Hospital last year, £6100 had come from this fund. Sir Russell's own Company, with a staff of 850, subscribed £320 towards that fund. Another scheme that reflected enormous credit upon those who organized it was the contributory scheme, which last year supplied £16,300 to the Hospital. That meant that £22,000 was contributed by the working classes to the institution. Sir Russell said that some time back it was found that there was a large sum of money standing to the credit of the workmen of the Company, and he had suggested that £1000 should be handed over to the Hospital. The Hospital authorities came to the conclusion that the best use to which the money could be put was to provide these balconies, which would provide the convalescing patients with sunlight and air.

General Byron, returning thanks for the gift, said all the four balconies faced south and so provided the maximum of sunshine. The gift was a real token of the workmen's belief in voluntary hospitals, which had been such a conspicuous feature of the national life for many years.

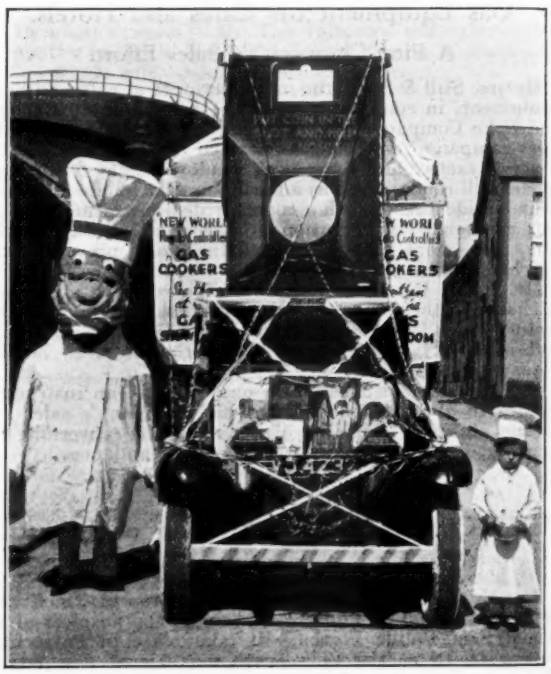
On behalf of the medical staff, Dr. W. Stewart expressed thanks for the gift, and said that the balconies had made the work of the medical staff easier.

Colonel Sir Edwin Perkins proposed a vote of thanks to the Mayor and Mayoress for their presence, and commented upon his Worship's keen interest in everything that dispensed charity. Sir Edwin expressed his great delight that the men had been ready and willing to provide money for the purpose of helping those who were not so strong and healthy as they were themselves.

Mr. Whitehead seconded the vote of thanks.

The tablet that Sir Russell unveiled by releasing a Union Jack bore the following inscription: "This balcony and that above it, together with two similar balconies in another part of the Hospital, were erected in January, 1933, from funds generously provided by employees of the Southampton Gaslight and Coke Company."

After inspecting the other balconies and the Hospital, the company were entertained at tea in the Board Room.



This photograph was taken at Ross on a recent Carnival Day. The giant Radiation chef figure, nearly 11 ft. high, makes an amusing contrast with the little daughter of the Manager of the Ross Gas Company, Ltd., Mr. F. C. Harris. The outfit was awarded third prize.

Tralee Gas-Works May Close Down.

We learn from the *Irish Press* that Tralee Urban Council's treasurers have refused further accommodation; and paying orders in favour of the Commissioners of Public Works, amounting to £1000 in payment of loan instalments due since June 1, are unpaid.

The Minister not having sanctioned the raising of a loan or given permission for the sale of the gas-works owned by the Council, the undertaking may be forced to close down this week, as the stock of raw materials will be exhausted, and there is no money to buy more.

THE INSTITUTION WHITSUN CRUISE

By One of the Party

Who could have gauged whether the idea of a Whitsun Cruise for members of The Institution of Gas Engineers would catch on? The scheme was novel, and new ideas sometimes require assimilation. If anyone could have prophesied perfect weather and as successful a week's holiday as the event proved, there might have been a more considerable response. After all, it was only an extension of that Friday excursion when members relax after strenuous attendance at the Annual General Meeting. Moreover, it was an attempt to get a little further away from gas and indulge in complete freedom for oxygen intake. We were not a very large company, and could easily get lost among the 510 passengers on board the R.M.S. "Lancastria." The Secretary, Mr. J. R. W. Alexander, had not himself booked for the voyage, but at the last moment was pushed on board by a grateful Institution to relax after his most efficient activities. And that was fortunate in more ways than one, for the Cunard Company were sensitive of our patronage as a Chartered Institution, and the Captain invited our Secretary to a special reception in his quarters.

An Oil-Burning Ship.

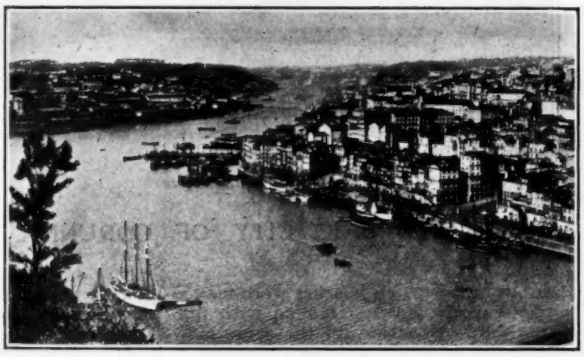
The "Lancastria," beflagged as though in our honour, sailed from Liverpool at 7 p.m. Saturday evening, June 3. She is a ship of 17,500 tons, with an excellent reputation for steadiness. The cruise covered 1709 miles in all, and occupied six days. During the voyage we had the privilege of inspecting the engine rooms. The ship is oil-burning, not oil-driven. Each of the two propellers is revolved by a steam turbine, transmitting through a steel shaft 19 in. diameter; making two completely separate units, port and starboard. The vessel carries many hundred tons of oil for heating the boilers; this is a residual oil of high flash-point, raised to a still higher temperature and compressed for atomization. The vaporizing jets are of special construction, comprising a centrifugal device and a nozzle, combustion taking place away from the nozzle itself. A certain amount of carbon is formed, and that is burned with forced draught.

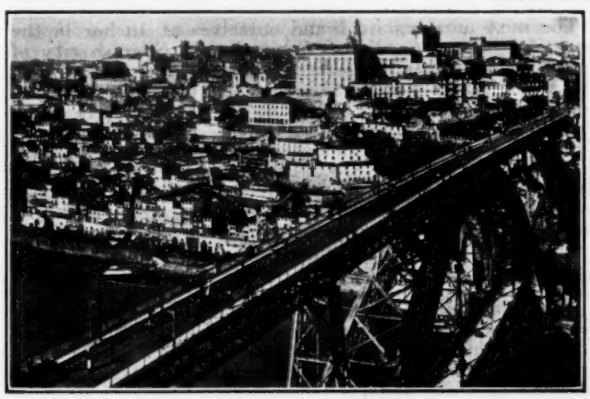
Sports on Board.

We did not, however, spend all our time down in the engine room, but found that on deck the holiday spirit was remarkably infectious. The Cunard Company have a "Cruise Director" on board who has studied the holiday fancies of passengers, and organizes the games and competitions, as also the shore excursions, in a delightfully free and easy manner; in fact, the absence of formality on board was notable. The sports followed the usual lines, with sundry novelties, including the provision of two swimming pools. In the Sunny South these open air baths were very popular, and fresh sea water was kept running in and out all day. A special deck was also reserved for sun-bathing. To complete the social picture, reference must be made to the extensive printing arrangements on the boat, by means of which programmes, instructions, and advices, punctuated by a spicing of humour, were daily distributed to every passenger. Artistic menu cards were retained by many passengers as a memento of the cruise.

Oporto.

We landed at Oporto on the Tuesday morning. This is the second city of Portugal, with 250,000 inhabitants, situated on both banks of the River Douro, in the best cultivated and most fruitful province in the country. Actually the harbour and landing stage are at Leixoes at the mouth of the river, and the town about three miles up. Visits such as ours are not very frequent, and we understood that the "Lancastria" was the largest vessel to enter the harbour and turn round therein. It happened to be a gala day, so that we saw the place in full fair. Wherever we went our party was received with tumultuous welcome. Our line of motor cars and coaches passed through almost endless streets lined with smiling folk in national costume. We could not help remarking the extraordinary number of women carrying loads on their heads, as though the staple industry of the town were porterage. We could not find any counterpart in the lady's handbag of our own country, particularly when the load consisted of





[*By courtesy of "Casa de Portugal," Portuguese Government Bureau, 20, Regent Street, S.W. 1.*

OPORTO—THE SECOND CITY OF PORTUGAL.

a crate of live chickens. Such signs in Portugal as well as in Spain are reminiscent of Moorish customs; but there were one or two robot traffic signals to bring the city streets up to date. The buildings on both sides of the river, rising in lofty terraces, are picturesque and impressive, and the fine steel bridge designed by the builder of the Eiffel Tower by no means detracted from the beauty of the scene.

Braga and the Great Stairway.

We passed over this bridge, both above and below, and proceeded on our way to Braga, a small town, or rather city, 30 miles further inland. Braga is a great religious centre, spoken of as the Mecca of Portugal, for nearby is the celebrated Sanctuary, " Bom Jesus do monte." *Toute personne parcourant Le Portugal ne peut pas quitter ce riche pays sans visiter Bom Jesus Do Monte.* Here is the wonderful stairway leading up to the summit of a hill nearly 2000 ft. above sea level. Each stage in the ascent is marked by a large shrine with life-size tableaux of scenes in Passion Week. From the top, there is a magnificent view of the surrounding country, and there are rambling woods and rock gardens and ornamental waters. The visitor is specially requested to walk down the Great Steps, because only thus can their setting be fully appreciated. Viewed from the base it is less impressive. This extraordinary monument is known as " The Stairway of the Five Virtues."

We had an almost civic reception at the hotel on the summit, where lunch was provided. There was in attendance a most creditable brass band of Portuguese Naval cadet boys, who played, among other excerpts, our National Anthem three times, and they played it exceedingly well. Each lady of the party was presented with a carnation, the gift of the Mayor, in honour of the visit of so large a party of English people to Portugal. We were never quite sure whether such honours were meant for the Cunard passengers in general or for the Gas Institution party in particular! A farewell telegram from the Mayor of Braga, wishing us a successful voyage and return home, was posted up in the boat on our leaving Portugal.

Motoring back to Oporto we passed again the local gasworks which members of our party had viewed with such complete unconcern on the outward journey. This time we raised our hats.

The Wine Lodges.

There was very little time left for the Wine Lodges at Oporto, but these proved a most interesting exhibit. They appear to be in the hands of British firms, and it is understood that in England the label " Port " may only be applied to wine from the Douro Valley. The wine is made in the country and collected from many vineyards to the " lodges " in the city. These " lodges " are stores where we saw thousands of barrels of port wine each containing 117 gallons. The barrels are called " pipes " when the contents are port, but sherry is contained in a " butt." There were larger barrels called " vats," and we saw one containing 13,000 gallons. We were told that aeration of the wine during preliminary mixing improves it. The final storage is arranged according to the date of maturity. We were hospitably received by our compatriots who carry on the business, and the ladies were presented with miniature samples. It was 8 p.m. before we returned to the " Lancastria " and our launches were pursued, as they had been met, by vendors of cherries.

Corunna.

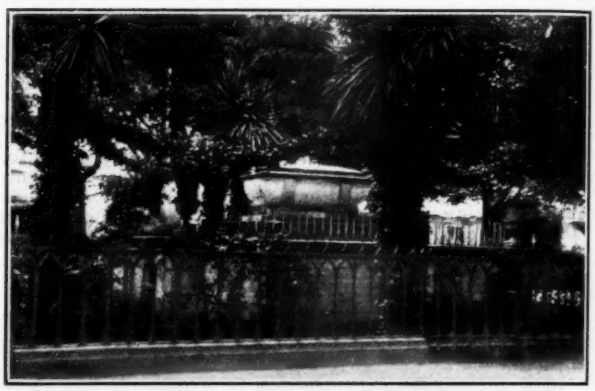
The next morning we found ourselves at anchor in the beautiful bay of Corunna. Corunna is a Spanish city of 100,000 inhabitants. Englishmen have a strong link with this place, for we were to visit the tomb of Sir John Moore, who there conducted his famous retreat during the Peninsular War. Beyond the town, on the heights of Elvina, we viewed the memorial marking the spot where Sir John Moore fell in 1809, struck by a cannon ball in the shoulder. The famous poem of Wm. Blake, " Not a drum was heard, nor a funeral note," is inscribed in full on a tablet in English at the tomb, which is in the town itself.

Santiago de Compostella.

The drive from Corunna to Santiago is 37 miles through fine scenery. A magnificent road, surfaced with Trinidad bitumen (shipped in barrels from England), rises to a height of 1300 ft. Hair-pin bends are flanked with parapets of white stone.

Santiago is described as one of the sights of Spain. The town, 800 ft. above sea-level, has 28,000 inhabitants and many more monuments than we were able to see during so short a visit. But the Cathedral is one of the oldest (intact) in Europe. It dates from the 11th century, and contains the traditional tomb of the Apostle James. The architecture is Roman and Byzantian. The church contains some wonderful old books and many interesting features. Adjoining it is a courtyard reminiscent of St. Mark's Square at Venice, surrounded by three institutions, the Hospital Real, the College of San Jeronimo, and the Consistorial Palace. Here we were shown a very fine collection of ancient tapestries. Our party was served with lunch at the Hotel Compostella.

We could have spent days at Santiago without exhausting its interest, but had to return the 37 miles to Corunna before the ship sailed at 5 p.m. The picturesque street scenes in Spain differed somewhat from those in Portugal, but we received the same cheerful welcome. In place of



[*By courtesy of W. T. & A. R. Blake, 199, Piccadilly, W. 1.*

1. The Municipal Palace.
2. Tomb of Sir John Moore.

THE HISTORIC CITY OF CORUNNA.

the women burden bearers were loaded mules and donkeys; and wagons drawn by oxen with fine long horns made a continual attraction for the camera.

Returning with the Armada.

As we steamed slowly out of the Bay of Corunna, regretting that our visit was so short, we were reminded that it was from here that the great Spanish Armada sailed for the destruction of England in 1588. Two years after, Sir Francis Drake returned the visit and sacked the town. Our visit was of a very different order.

Two more days at sea with continuance of good weather and pleasurable sports brought us back to Liverpool on Friday, June 9, everyone voting that the cruise had been a delightful experience. Our " gas " team, competing under the *nom-de-plume* of " The Therms," won the tug-of-war; and various other trophies were taken at the prize-giving by Mr. Alexander and others. One of our party exclaimed on the last morning, as we sighted Land's End, and while the band was playing Auld Lang Syne, " Good old England, but I wish I were back in Santiago."

The members of the Institution who participated in the cruise owe a debt of gratitude to Mr. R. Foulkes, of the Cunard Company, who took quite an exceptional interest in the preliminary arrangements, and also to Captain Guy R. Dolphin, R.D., R.N.R., and the officers and crew of the " Lancastria."

International Road Tar Conference

Opening Speech by the President, Sir David Milne-Watson

Last week an International Road Tar Conference was held at Lucerne under the Presidency of Sir David Milne-Watson, LL.D., D.L.

Opening the Conference, Sir David said: It is my duty—and a very pleasant duty—to extend to all the delegates a most cordial welcome to this Conference. The presence of so many eminent personalities who take an interest in the problem of road tar and its adaptation to the needs of highway transportation, is perhaps the best proof of the importance of the subject we have gathered here to discuss.

When, just over two years ago, you did me the honour of electing me as your first President of the International Road Tar Conference, I accepted the office with the greatest possible pleasure for two reasons. First, because I regarded it as a compliment to the excellent progress that has been made in the development of road tar in Great Britain, and, secondly, because I believe that a Conference of this character provides the best medium to exchange views upon a subject in which we are all interested. It is said that the history of roads is the history of the growth of civilization, and I venture to suggest that modern road development is in no small measure due to road tar. Certain it is that tar was the earliest of all modern road-making materials, and to no small degree, in fact, the tar road may claim to have contributed to the phenomenal advance in motor transport, since without suitable carriageways many of the achievements of modern motor vehicles would have been impossible.

If I take pride in the progress of road tar in Great Britain, I do so because, as President of the British Road Tar Association, I am familiar with the work that has been done to make known the excellent qualities of road tar for the construction and maintenance of roads in my country. Progress must always be sought and expected; yet the crucial importance of maintaining and extending the market for road tar demands that accumulated experience shall be accorded its full significance in considering the problems that confront us to-day. It is in this respect that I consider the national road tar organization of each country can be of real value. Fundamentally, progress in any industrial activity depends on knowledge of the facts, and it should be the duty of each national body not only to collect and compile the facts, but to consider the application of the facts to practice. In addition, each national body can act as sponsor for that research which must always precede improvements in any sphere, and if this is done in conformity with the special requirements of each country, and under the impulse of its own national genius, I am confident that it would conduce very greatly to the progress of road tar.

There is, however, another aspect of this question, to which I attach the greatest importance, and that is that, although the tar resources of different nations may vary in nature and amount, many of the problems involved in their more efficient utilization are general. This being the case, it is to the common advantage that the results of study, experiment, and experiences should be pooled. It is with this object in view that the International Road Tar Conference was formed, and it not only brings together those whose work is connected with the production and distribution of road tar, but it allows of their collaboration and closer contact with each other, through discussions of the most recent technical developments and practical experiences connected with the subject. In my view the Conference is to be congratulated on its energy and enthusiasm in promoting an undertaking which cannot but prove of great usefulness to everybody concerned.

My tenure of office as your President terminates with this meeting, and in thanking you for the support you have given me during the last two years, I would only add that mutual help, the purging of suspicion, the abnegation of selfishness are the great needs of the world to-day, and not least in the sphere of research. In helping one another we need not fear that we shall not be helping ourselves. It is in this spirit, and with this hope, I desire to commend to all whom it concerns the International Road Tar Conference.

New Officers.

President.—Herr Generaldirektor Dr. Spilker, President, Verkaufsvereinigung für Teererzeugnisse, m.b.H., Essen, Germany.

Vice-Presidents.—Monsieur Laurain, President, Comité Central des Producteurs et Distillateurs de Goudron en France, 4, Rue Condorcet, Paris; Sir David Milne-Watson, LL.D., D.L., President, British Road Tar Association.

Chairman.—Herr Direktor Möllers, Verkaufsvereinigung für Teererzeugnisse, m.b.H., Essen.

Secretary.—Herr Direktor Laeger, Auskunft-und Beratungstelle für Teerstrassenbau, E.V., Essen.

The meeting terminated with a hearty vote of thanks to the President, Sir David Milne-Watson, the Chairman, Mr. Reginald Clarry, M.P., and the Secretary, Mr. W. E. Cone, for the services they had rendered since the inauguration of the Conference two years ago.

Filled Tars*

By P. Le Gavrian, D. Boutet, and G. Bedaux.

The word "filler" has been used for a long time for mineral substances incorporated in bituminous concrete to fill up the voids. This word has also been used by analogy for mineral compounds incorporated in tar or tar-bitumen mixtures.

In a patent dated Aug. 10, 1918, and granted to the Rütgerswerke, it is claimed that an addition of finely powdered coal to tar improves the quality of that substance when used in the preparation of bituminous cardboard. In the same patent it is said that this principle may be extended to road tar, but, in fact, practical application by the Rütgerswerke of that patent to road tar is not known or claimed.

In or about the year 1925, the Road Department of France, and more particularly M. Le Gavrian, directed M. Leauté, Director of the Société de Recherches et Perfectionnements Industriels, towards the possible incorporation of finely ground coal to tar. The idea was probably to have a remedy for a possible scarcity of tar. During the "Tar Days" (July, 1928), M. Leauté explained that a coal filler could be incorporated with the tar, within a proportion of 50% of the total weight of the mixture. Tar did not lose any quality, and remained sufficiently fluid when spread; no modification of the method used had to be foreseen. Resistance to wear, as well as rapidity of setting, was increased; the surface was less slippery. A practical experiment was made at the Ranelagh.

As this filler was less expensive than tar, the filled tar would not be so dear as the tar itself.

In 1931, appeared in England the classical work of Mr. Evans and Mr. Pickard (the latter having unfortunately since died) entitled "An Investigation into the Nature and Properties of Coal Tar." This work has been summarized splendidly by M. Le Gavrian in the "Annales des Ponts et Chaussées" (1932, I., and 1932, VI.).

The authors show that the consistency C of the tar at a temperature T is such that $C \times T^n = a$, which by logarithmic transforming gives a straight line as a curve of variation. If several tars are prepared, those characteristic lines meet in a focus, which proves that at a certain temperature the viscosity of different tars is identical. This seems to be true also for asphalt, but the focus is not the same. If the tar is modified—*i.e.*, by addition of a filler—the focus is modified and the characteristic curve is translated parallel to itself.

Practical experiments have been made in France, and reported in the "Annales des Ponts et Chaussées" (1932, VI.). The results obtained confirm the assertions made by

*Abstract of Reports before the International Road Tar Conference, Lucerne, June 14, 1933.

M. Leauté in 1928, and the theories expressed by Evans and Pickard.

Fillers other than coal may be foreseen, and M. Boutet used both coal and Wizerne limestone. The author shows what must be the relation between the size of the filler, the specific gravities of filler, and bituminous substances. He also gives curves of equal viscosities.

Cohesiveness of those filled tars has been studied by M. Berger, and the results are recalled in M. Boutet's report.

The cost of material and of spraying is given, but we must remember the quantities figures only, as the administrative accounts are quite different from the industrial ones.

To conclude, M. Boutet gives results of practical work and hints. M. Bedaux in the same way gives the results of his practical experiments.

We may admit that the difference of viscosity between the spraying and the actual temperatures plays an important part. At spraying temperature we must have a very fluid substance; at the actual temperature, the product must be as viscous as possible, if a quick setting is desired. The addition of a filler allows of a larger difference of viscosity between the two temperatures than with pure tar.

Until now, coal and Wizerne limestone have been studied; other substances may also be used, such as shales.

Cold Tars*

By Prof. Dr. MALLISON, Berlin.

In Germany we understand by the expression cold tar a road tar which, by the addition of an easily volatile solvent, is diluted to such an extent as to enable it to be laid on the street in liquid form at the usual temperature. Certainly tar emulsions are also cold fluid, but the cold fluidity of these emulsions is achieved by the tar, as an emulsoid, being distributed in the finest droplet form in water acting as a continuous medium. Whereas tar emulsions lose for the most part their water and become agglutinative through breaking and also through vaporization of the water, the cold tars acquire their binding qualities only through the vaporization of the easily volatile oil which is added. It is true that aqueous cold tars have also existed containing a certain amount of water as well as the easily volatile oils, but they represented intermediate links between the genuine cold tars and the water-in-tar emulsions, and they have vanished from the market.

THE QUESTION OF NOMENCLATURE.

Attention must be directed to the fact that a certain confusion in regard to the nomenclature of these cold liquid binding materials prevailed. The asphalt industry understood by the expression "cold asphalt" not an asphalt solution, but an emulsion of asphaltic bitumen. The tar industry took the lead here in distinctly separating the ideas, with the result that the asphalt industry in its turn has recently determined to make a distinction between bitumen emulsion on the one hand, and cut-back asphalt on the other.

Strictly speaking, one should understand by a cold liquid binding material a substance which permits of being applied to the street, laid on and sprayed, without heating, at any temperature—*i.e.*, in any season. Such a demand is not easy to meet. This degree of fluidity can, of course, be obtained without difficulty either by selecting a thin fluid starting tar, or by adding to a viscous tar very considerable quantities of solvent. Both methods, however, have their drawbacks. A cold tar proceeding from a thin fluid tar obtains the binding power sufficient to bind the stone only after too long a time has elapsed; again, a cold tar with much solvent contains little binding substance, and is also relatively expensive. It was a question, then, of finding a middle way. To all appearances the development follows two different courses. Either a cold tar is prepared, which in summer possesses the correct thin fluidity, but which must be heated up a little in cooler seasons, or two kinds are placed on the market—a thin liquid and a more viscous kind, which are applied according to the season. It will also depend on whether or not the consumer possesses spray devices capable of being heated; according to circumstances he will decide on the cold tar which can be heated, or on the thin fluid cold tar. It also makes a difference whether the cold tar is to be used merely for painting damaged places or for surface tarring with spray devices, or for the manufacture of tarmacadam (by shovelling together or in mixing machines).

Thus the whole question of viscosity of the cold tars cannot be answered simply by saying the cold tar must always be essentially thin liquid. Allowance must be made here for economic considerations, the peculiarities of the application, and, finally, the respective purpose to be achieved.

Naturally a high degree of fluidity of the cold tar can be arrived at if a very rapidly boiling and vigorously liquefying solvent is used; preparations of this nature are also on the market and enjoy extensive application. Again, they possess the drawback, however, of being very easily inflammable. Despite the fact that they are really not to be heated, there still remains the danger of their being heated in case of need, or inadvertently coming into contact with fire, owing to carelessness. Hence one sees, when deciding on the selection of a cold tar specification, that "there are two sides to everything," and, generally, of necessity the decision amounts more or less to a compromise.

There is still another point to be added, which must play a part in the preparation of a cold tar, apart from viscosity and inflammability, and that is the question of whether one desires to bind stones—*i.e.*, repair a hole or prepare a tarmacadam—or to carry out the restoration of an old tarred surface. In the first two cases, it will mean a high content of vigorously binding substance—*e.g.*, an agglutinant pitch. In the last one, however, it will depend on a certain content of tar oil which is able to soften and make the hardened layer of tar pliant again. Both spheres of cold tar application have gained great importance in Germany.

If we summarize the foregoing, it will be evident that the laying down of clear simple rules of quality for cold tar is fraught with unusual difficulties. The merit of having made the first start here in Germany, and of at least having laid down a preliminary outline for such rules, belongs to the Deutschen Strassenbauverband.

These rules are as follows:

	Cold Tar I.	Cold Tar II.
1. Viscosity in the road tar consistometer (nozzle 4 mm.) at 30° in secs. . .	Under 20	20–150
2. Water, not more than % by weight .	0·5	0·5
3. Heavy oils and anthracenic oil together at least % by weight	16	16
4. Pitch residue, converted to 67° m.p., at least % by weight	40	50
5. Phenols, not more than % by volume	3	3
6. Naphthalene, not more than % by weight (incl. analyt. approximate limit)	3	3
7. Crude anthracene, not more than % by weight (incl. analyt. approximate limit)	3	3
8. Free carbon within % by weight . .	4–16	4–16
9. Flash point (Pensky Martens) . . .	To be stated*	To be stated*
10. Content of ash, not more than % by weight	0·5	0·5

* Easily inflammable cold tars must bear a special reference on the barrels.

If we examine these figures in detail, we see at first a fundamental separation of a thinner kind I. and a thicker kind II. The measuring of the viscosity proceeds with the consistometer at 30° in the same way as with the German hot tars; as, however, the 10 mm. nozzle would cause a too rapid and inaccurate reading of the cold tar discharge, a nozzle of 4 mm. diameter has been inserted in the consistometer for this purpose, and we then receive second values which are easy to read. The limit thin fluid: viscous has been laid down at 20 secs. In order to make clear to the roadmaker the meaning of these figures, it should be mentioned that a range of 20-150 secs. with the 4 mm. nozzle corresponds approximately to a range of 1-5 secs. with the 10 mm. nozzle. The more viscous cold tar would accordingly be approximately as viscous as the thinnest standard hot tar.

The limit of 20 secs. was so selected from practical experience, because cold tars can be sprayed with this or with a lower viscosity even at lower temperatures without

* Paper before the International Road Tar Conference, Lucerne, June 14, 1933.

heating, whereas cold tars whose viscosity lies considerably above 20 secs. require heating up to 30°-50° in cool weather.

Distillation Limits.

With regard to the distillation limits, the statements in the table have been kept intentionally brief and vague, as the preparer must be granted a certain liberty here, and the variety of the solvents naturally forbids the laying-down of more accurate statements. The figures for oils, pitch residue, phenols, naphthalene, crude anthracene, and free carbon have, therefore, only been put forward to demonstrate the combination and to prove that a good road tar served as a basis for the preparation of the cold tar.

Flash Point.

The determination of the flash point gives the analyst an idea as to the nature of the solvent and to the practician a gauge as to the inflammability. The flash point must be determined in the closed crucible, Pensky-Martens apparatus, for when heating in the open Marcusson crucible very light parts of the solvent, such as carbon disulphide, would vaporize even during the determining of the flash point. This would cause one to be misled into determining the flash point too high. In this case, the danger would be present in practice of explosive mixtures of air and solvent vapours forming in half-filled barrels, which, when handled carelessly (lighted cigarettes, &c.), could lead to the explosion of the barrel. Experience has taught that a limit must be drawn at a flash point of about 30°; in cold tars having higher flash points danger is practically non-existent.

If a Pensky-Martens apparatus is lacking, this can be shown in the following way. Fill a ½ litre bottle about half-way with the cold tar to be tested, and leave the bottle standing, well corked, for about two hours. Afterwards draw the cork with the left hand and with the right dip a lighted match into the air-filled space above the cold tar. Observe when doing this whether a flash occurs or not. This test is perfectly safe and yielded a clear illustration in the preparations tested by me.

Tests for the Practician.

From the sum total of the analytical figures spoken about up to this point, the chemist, of course, can with some practice draw his conclusions as to the prospective behaviour of the cold tar on the road. For the practician, however, it is not sufficient; he requires more illustrative information regarding the rapidity of the binding; he demands an answer to the question how quickly the solvent vaporizes and what degree of fluidity is arrived at by the tar residue after vaporization of the solvent. Only then is the practician in a position to judge whether a determined cold tar preparation is suitable for repairing street holes, for the preparation of mixture surfaces, or for the care of tarred surfaces. In accordance with this, for measuring the qualities of the cold tars a number of tests have also been proposed. One proceeded along two lines:

1. A weighed quantity of cold tar is left standing in a flat bowl partly at a room temperature, and partly under heat in the heating oven, and after a certain time has elapsed, the loss of weight is ascertained. The wording of the specification of the Deutscher Strassenbauverband referred to is as follows:

"*Loss of Weight.*

"Weigh up 50 g. of the cold tar in a previously weighed bowl of brass measuring 12·8 cm. interior diameter (surface 128 sq. cm.) and 1·5 cm. interior depth, and distribute the cold tar as evenly as possible. Now place the bowl horizontally in a place free from draught and dust, with a room temperature as far as possible invariable (approx. 20°) avoiding the sun's rays. After a lapse of 3 days the loss of weight is ascertained in percentages.

The loss of weight in a room temperature can be determined in a like manner after 10 days and 30 days.

Further, the loss of weight at 50° can be ascertained in 5 hours and 10 hours, by placing the bowl with 50 g. of cold tar horizontally on a stout wooden block in a heating oven previously heated up to 50° whose temperature is retained at 50° with 1° of exactitude. Afterwards cool and weigh the bowl in a desiccator."

Naturally, the examination of the consistency the residue has assumed after vaporization of the solvent is also important. As the residual quantity obtained is too limited to determine the viscosity, it is preferable to determine the dropping point according to Ubbelohde instead. Now that we know that a road tar 70/30 possesses generally a dropping point of approximately 25°-35°, we can judge what viscosity the residue possessed in comparison with a hot tar —*i.e.*, how the matter stands regarding the binding quality of the cold tar following vaporization of the solvent. I myself carry out this test by placing 15 g. of cold tar in a flat bowl of 10·5 cm. diameter and heating it up to 50° in the oven for 6 hours.

2. Another method—in accordance with practice—is to prepare a mixture of cold tar and gravel, let the mixture stand, and after a certain time examine its condition. The Deutscher Strassenbauverband has proposed the following as a means of executing this method.

"*Binding Test.*

"With a broad wooden spatula carefully mix in a brass bowl with flat bottom and approx. 12·8 cm. bottom diameter 100 g. dry basalt gravel, free from dust, size 3/7 mm., with 5 g. cold tar until it is uniformly covered. The depth of the layer of covered gravel now amounts to approx. 1 cm. After a lapse of 24 hours the gravel covered with cold tar should form a cohesive substance—*i.e.*, no covered particles of gravel should fall out when the bowl is held at the perpendicular (at least 15 secs.). Carry out the test under room temperature, but not in direct sunshine.

Cold tars not able to stand the binding test are to be offered with a special reference to same."

P. Schläpfer (Schweizerische Zeitschrift für Strassenwesen, No. 7, 1932) prepares a mixture of 250 g. gravel (equal quantities of sizes 2-5 mm. and 5-8 mm.) with 12·5 g. cold tar, stamps this mixture into a flat square frame (9 by 9 by 3 cms.), and then examines the resulting form after a more or less lengthy period to determine its exterior condition and consistency.

We see that methods (1) possess the advantage of supplying numerical values and thus giving the chemist good information; methods (2), on the other hand, give more satisfaction to the practician, but suffer from the fact that their application is left more to feeling than to measurement. I think that the two methods must be more thoroughly elaborated. In addition, I would like to say the following:

From the treatment which some specialists accord to the cultivation of these methods, one might form the opinion that the preparation of a cold tar was purely a question of making it as quickly binding as possible; the method (binding test) of the Deutsche Strassenbauverband repeated above has obviously been laid down accordingly. I believe, however, that the state of things is more complicated here. It is self-evident to me that the methods of testing a building material must conform to the claims which the material must satisfy when applied in practice. As I remarked at the beginning, the cold tars serve various purposes, and, according to the respective purpose, a rapid or a slow binding may be desired—*e.g.*, a cold tar which is to be used to restore an old and hardened tarred surface will have to be rich in oil; it therefore cannot stand the binding test of the Deutsche Strassenbauverband, as the residue will be more or less fluid after the solvent has vaporized, and will not be able to hold the gravel. On the other hand, if a tar concrete consisting of cold tar and stone mixture having a minimum of voids is to be prepared, it will be well if the solvent vaporizes very easily and rapidly and a very binding tar remains. The development then will have to follow the line of the methods of examination being more closely adapted for the purpose. I can well understand a vaporization test being introduced generally in accordance with (1) in order by this means to ascertain numerically what consistency may be achieved by the binder after vaporization of the solvent has taken place. But for the gravel test in accordance with (2) a fundamental distinction should be made between cold tars for "binding" and cold tars for "oiling." In the gravel test, the cold tars for agglutinating should supply, as soon as possible, a tough binding substance which in its properties corresponds to a tar gravel prepared under heat. In contrast, cold tars for oiling will have to leave behind a movable tar gravel substance.

Finally, if I look at the cold tar regulations in other countries I find that only in America is there anything to correspond with the German regulations. H. Lewis (Roads and Streets, 461, 1932) published the following regulations.

This tabulation shows in itself that the viscosity values for the American cold tars lie in about the same viscosity plane as the German, except that the sub-division in America goes into considerably more detail. The German

Purpose.	American Regulations. Viscosity Engler at 40° C.	Contrast Values According to German Standard. Viscosity in the Road Tar Consistometer at 30° (4 mm. Nozzle).
First tarrings with specially compact surface	5— 8	..
First tarrings	8—13	ca. 15 secs.
,, ,,	13—18	,, 30 ,,
Surface treatments	18—25	,, 40 ,,
,, ,,	25—35	,, 60 ,,
Repairs	35—60	,, 100 ,,
,,	60—80	,, 150 ,,

cold tar I. with a viscosity under 20 secs. corresponds to the two thinnest American cold tars; for the more viscous German cold tars (called cold tar II.) the regulation of the Deutscher Strassenbauverband at present knows only the collective range 20-150 secs., whereas the American cold tars are subdivided within this range into five lower groups. This shows that America has made more progress in the development of particular types of cold tar for special purposes, but it remains to be tested whether such an extensive specialization is necessary in practice, and, if so, what elaboration the German regulations would still have to undergo in this respect. Strictly speaking, fundamental efforts must be made on the one hand to keep the number of types as low as possible, and, on the other hand, to form the testing methods as carefully and as efficiently as possible.

Tar Concrete*

By W. E. Cone, Technical Adviser, British Road Tar Association.

The study of the problems of design of tar concrete mixtures requires, as a first step, a knowledge of the factors which control resistance to displacement under traffic—durability and a safe surface. To withstand resistance to displacement a compressed paving mixture should possess the maximum amount of structural strength and stability. The former is mainly dependent upon the mineral aggregate which constitutes the entire framework of the structure, and the latter upon the particle sizes of mineral aggregate and the fineness of the mineral filler, the characteristics of the tar, and the relative proportions in which they are combined. The durability of the mixture is mainly dependent upon its density in the compressed state, which in turn is governed by the characteristics of the tar and the extent to which it is incorporated in the mixture. The safety of the surface is mainly dependent upon the particle sizes of the aggregate and the method of construction.

With a knowledge of the factors which control resistance to displacement—durability and safety—consideration can be given to the design of mixtures suitable for light, medium, or heavily trafficked roads. In this respect, the desirable ideal would be a mixture possessing all these characteristics in a maximum degree; but as it is not likely that this could be achieved without sacrificing one for the other, it only remains to design a mixture whose variations in characteristics are not too widely divergent.

Stability Values.

The method of assessing values for stability is usually based upon the void content of the compressed mineral aggregate and the mixture. Having regard to the very large number of variations that can be made in the grading of the aggregate and the proportions in which they are combined, it is not intended to deal with this question from the standpoint of preparing different specifications, which call for a given mixture or mixtures being laid to varying thicknesses, in one or more courses, but to consider it only in relation to the design of a single mixture capable of satisfying the maximum traffic demands that will be made upon it. In the author's opinion, there is no need for a multiplicity of specifications for road mixtures—at least, as far as tar concrete is concerned—if careful consideration is given to design in relation to traffic requirements, and that before laying the material proper corrective measures have been taken to ensure the stability and permanence of the foundation, which really supports the traffic.

With this digression, the question of a specification for what may be termed a heavy traffic mixture can be further considered. As already stated, stability is controlled by the void content in the compressed mineral aggregate and the mixture, but, in addition to this, consideration has to be given to its structural strength and safety. The latter consideration at once rules out the possibility of designing a mixture consisting of only finely divided particles of mineral aggregates, for the reason of their tendency to become highly polished under traffic, and other disabilities arising from the construction, which will be dealt with later on. This danger can be overcome by the use of a combination of coarse and fine aggregate, in which the former predominates. The fine aggregate serves as a void filler for the coarse aggregate, and the addition of a proportion of mineral filler is of value in reducing the voids of the total mineral aggregate. With this as a guide, the mixture can be designed on the principle of the densest mix of evenly graded aggregates, in which the amount of tar incorporated is equal to that required to fill the voids in the compressed graded mineral aggregate. By these means, it is possible to control resistance to displacement and safety of the compressed mixture.

* Paper before the International Road Tar Conference, Lucerne, June 14, 1933.

Durability.

With regard to durability, the density of the compressed mixture will largely determine its resistance to weathering, provided, of course, that the characteristics of the tar and the extent to which it is incorporated in the mixture are in accordance with requirements. Here it is important to remember that the durability of the pavement can be materially affected by neglect to ascertain the amount of binding material required for a given mixture. Too little will be responsible for a pavement lacking in strength, with liability to crack under changes of temperature conditions, and too much will lead to softening and distortion under traffic. As already indicated, it would seem desirable to strike a happy medium in attempting to obtain maximum values both for resistance to displacement and durability. While it is possible to achieve a high degree of stability in the mineral aggregate by reducing the voids to a minimum, the amount of binder necessary to fill the voids might prove insufficient to ensure the requisite degree of durability. Similarly, the amount of binder required for a high void aggregate might result in a mixture of low stability. From this it will be seen that reasonable values for both characteristics would be more likely to be obtained from a medium void mixture than from any other.

In a number of practical road experiments, carried out by the author over twelve years ago, an attempt was made to investigate the possibilities of fine aggregate tar concrete mixtures for heavily trafficked roads. The aggregate in each case consisted of $\frac{1}{8}$ in. gauge material down to filler, using high consistency tars and soft pitches of known characteristics as the binder. With the object of arriving at values for given types of mixtures, the proportions of the constituents were varied, and such changes made in the manufacture and laying of the materials as were necessitated by the type of mixture employed.

In the majority of cases, the mixtures were laid as a wearing surface on an approved foundation to an approximate consolidated thickness of 2 in. In other cases, the mixtures replaced the "topping" in the construction of two-coat tarmacadam. The results obtained from these investigations were extremely interesting and revealed two principal defects which would appear to be common to all types of fine aggregate mixtures—namely, a tendency for cracking to take place under lowered temperature conditions, and liability of the surface to become highly polished under traffic. It was also noticed that partial softening of the pavement under the influence of hot weather and heavy traffic was responsible for slight distortion, and a tendency to wave formation. So far as could be ascertained, the defects referred to had no relation to inadequate foundations, but in the case of those mixtures laid on a base-course of tarmacadam there was evidence that the unstable nature of the base-course had been a contributing factor to the cracking and partial disruption of the tar concrete wearing surface. A careful examination of the pavement revealed quite clearly that, under the influence of heavy loads, the whole structure was subject to a slight rocking action, the origin of which was eventually traced to movement taking place in the base-course material. The strains set up by this movement were sufficient to cause cracking to take place in the more rigid wearing

surface, and enlarge those already formed in the pavement, due to other causes.

Coarse and Fine Aggregate Mixtures.

A careful review of the facts relating to these experiments led the author to the conclusion that the principal weakness of fine aggregate tar concrete compressed mixtures lies in their incapacity to maintain the requisite degree of structural strength necessary to prevent distortion and rutting of the pavement taking place under the combined influence of high sun temperatures and heavy traffic. In this connection, it is not suggested that a mixture cannot be designed to overcome the disabilities referred to, but rather that it can only be done at the expense of the brittleness of the pavement under lowered temperature conditions, which inevitably leads to cracking in the surface. The introduction of a substantial proportion of coarse aggregate in the mixture is of value in increasing the structural strength of the pavement, with less liability for cracking to take place, and it also ensures a safe surface. It would appear, therefore, that fine aggregate tar concrete mixtures would be less serviceable for heavily trafficked roads than would be the case where the coarse and fine aggregate mixtures are used.

For the reasons already stated, the author considered the possibility of designing a mixture in a manner which would, as far as possible, provide for all the desirable properties to be embodied in a single structure, as opposed to the customary practice of achieving the same end by the employment of two mixtures in the form of a base-course and a wearing surface. If, as already suggested, it can be shown that a single compressed mixture is as capable of meeting traffic requirements as that of two compressed mixtures, there would appear to be no justification for the employment of more than one mixture. The obvious weakness of two-coat tar concrete, or, in fact, any other similar type of bituminous work, is that the method of construction must result in inequalities in the resultant structure, due to the difficulty of obtaining a perfect bond between two structures of dissimilar characteristics. As apart from the elimination of the disabilities referred to by the employment of a single mixture, considerable economies could be effected by its adoption.

A series of experiments on the lines indicated resulted in the design of a mixture consisting of evenly graded aggregates ranging from 1 in. down to filler, and a soft pitch of coal tar. The amount of filler was limited to 5% and the matrix to from 8% to 10% according to the void content of the mineral aggregate. With the object of testing this mixture under heavy traffic conditions, it was first used as a wearing surface superimposed on a base course of tarmacadam. The results obtained were not as satisfactory as they might have been, but the experiment was of great value in determining the best conditions under which the material should be manufactured and laid. As a result of the knowledge and experience gained, certain changes were made in the manufacture and laying of the material, and it was decided to omit the base course and lay the mixture in single unit form direct on the foundation. The results obtained in this case were most satisfactory, and clearly indicated the advantages to be derived by the employment of a single compressed mixture.

At a subsequent date, the author's Specification for single-coat tar concrete was adopted by the British Road Tar Association for the construction of two test sections on the Kingston By-Pass. Full details regarding the Specifications and the tests that have been carried out on these sections will be found in the Reports for the years 1930-31 of the Technical Advisory Committee of the Ministry of Transport, a perusal of which would well repay all those interested in the subject of tar concrete. While in the case of these particular experiments the materials were laid on a concrete foundation, further tests have been made with similar mixtures on a water-bound road. The evidence to date shows quite clearly that the material can be laid on any well drained and strong foundation, and laid in the manner described is capable of withstanding very heavy traffic conditions.

Method of Application.

Concurrently with the study of the problems of design of tar concrete mixtures, the conditions governing their successful application can be considered. In the first place, the selected mineral aggregate should possess sufficient toughness and resistance to abrasion to withstand the impact of traffic and consist of angular particles, free from deleterious matter. The selected mineral filler should be of a fineness that not less than 75% will pass a 200 mesh sieve. Careful attention should be given to the character and grading of the mineral aggregate and filler, after which the varying sizes of the selected aggregate approximately proportioned should be fed into an elevator terminating and discharging into a rotary or stationary dryer, and, after heating, should be elevated and passed through a rotary screen having sections with various sized openings corresponding to the sizes of the mineral aggregate required by the specification. The several sizes of aggregate thus separated should pass into a bin containing the requisite number of compartments for the reception of the materials. The heating arrangements should be controlled in a manner which will ensure the aggregate being at a temperature between 230° F. and 260° F., when ready for mixing.

The weight of each batch mixing having been decided upon, the calculated quantity of each size of aggregate should be separately weighed or measured, and discharged into a properly designed mixer. The soft pitch, having been previously heated and brought to a temperature between 230° F. and 260° F., should be added in sufficient quantity to coat all particles and fill the voids in the compressed aggregate. In practice, it will be found that one ton of compressed mixed gauge aggregate requires from 8% to 10% of matrix. It will be found advantageous to heat the mineral filler separately to the same temperature as that of the aggregate, *and add the calculated quantity for each batch during the mixing operation.* When the materials have been thoroughly and intimately mixed, which usually takes about 2 to 3 minutes, they should be discharged into the lorry below.

On completion of the mixing, the tar concrete should be sheeted and immediately hauled to the road. The material should be discharged into medium sized heaps, and while still hot, spread evenly with heated rakes or shovels on the prepared foundation to sufficient depth to provide a consolidated thickness of 3 in. after rolling. The rolling should be carried out as soon as possible, using an 8 to 10 ton roller, and continued until all roller marks disappear, and the surface gives indications of no further compressibility. In order that the number of joints between the hot and cold material may be reduced to a minimum, arrangements should be made for the laying of the material continuously. When laying new material abutting on that previously consolidated, the cold material should be trimmed down to a rough bevelled edge, and the hot material raked over it, and thoroughly rolled.

After the rolling of the material is completed, the road should be immediately opened to traffic, but in the event of its being considered necessary to fill any unevenness in the surface, a seal coat of tar, complying with British Standard Specification for Tar No. 3, No. 76, Part 2, 1931, should be spread over the surface. It should be applied at a temperature between 220° F. and 260° F., by pressure distribution, gravity painting, or any other approved method, in just sufficient quantity to flush the surface voids without leaving any excess. Immediately after the application of the tar a top dressing of approved chippings, free from dust, of ¼ in. to ½ in. gauge, should be spread and thoroughly rolled into the surface. The gritting material should be dry, and in cold weather should be heated.

The type of construction described will generally give good service under traffic up to 30,000 tons a day, and will not require any further treatment for three to five years.

CONTINENTAL NOTES

INCREASED BENZOLE YIELD FROM COKE OVENS.

W. Busch, A. Colin, and H. Schmitz, in *Glückauf*, 1933, 69, 490-493 (June 3), describe experiments carried out on a 16-in. oven with a view to improving the benzole yield by restricting the excessive amount of cracking which was apparently a feature of the battery in question. To this end, modifications were made in the method of exhausting the gas—namely, by removing it by way of the charging holes into a collecting flue without allowing it to traverse the length of the gas space. The bottom of the ascension pipe was shut off, and a connection made between the collecting flue and a point some way up the ascension pipe.

Observations were made over each two-hour period of the carbonizing time. The gas contained less hydrogen, more methane, and slightly more unsaturated hydrocarbons and carbon dioxide than under previous conditions. The benzole concentration and the specific gravity of the gas were increased. The temperature of the gas in the ascension pipe was approximately 730° C. for the first 12 hours of carbonization under the new conditions and then fell fairly rapidly to 300° C., whereas previously the temperature was 800° C. for the first 16 hours and fell only to 700° C. at the end of 20 hours.

The yield of once-run benzole per ton of dry coal was increased from 2·5 gallons (specific gravity 0·874) to 2·7 gallons (specific gravity 0·876), and the benzole was much lighter, showing under the modified conditions, 82% to 100° C. and 98% to 168° C., as compared with 73% to 100° C. and 96% to 187° C. under previous conditions.

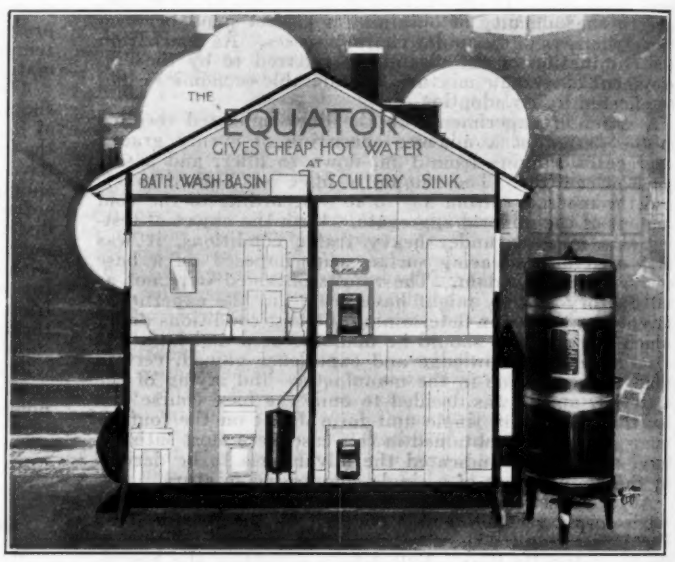
SELLING HOT WATER AT CROYDON

Forceful Gas Storage Heater Display

EFFECTIVE "EQUATOR" DISPLAYS ON EITHER SIDE OF THE MAIN ENTRANCE TO THE CROYDON GAS COMPANY'S KATHARINE STREET SHOWROOMS.

The Croydon Gas Company, ever alert to the possibilities of the modern gas water-heating appliance, are making a special feature of Richmond's "Equator" in all their seven showrooms. The many important advantages of this popular thermal storage heater will thus be brought prominently to the notice of their consumers not only in Croydon Town, but also at Purley, Norbury, Thornton Heath, Wallington, Caterham, and Oxted. At each of these showrooms the window space is reserved for the "Equator" for from seven to ten days. Large window bills with suitable slogans assist the pulling power of the displays and heaters set out in the windows. Two of our photographs show three of the windows at Katharine Street, Croydon. A pleasing colour scheme of primrose-yellow and blue adds much to the attractiveness of the general layout, and carefully worded "Reader" cards convey a brief convincing message of "What it does" and "How it works." Heaters of 12, 18, and 25 gallons capacity are being shown, and these are in both black and silver "Lustre finish and also in white porcelain enamelled finish.

It is also interesting to note that the Croydon "Equator" scheme goes beyond the window displays. The interiors of their showrooms are also being specially arranged for visitors to see the "Equator" fitted and in operation. A large sectional view of a house (see the above illustration) is part of the interior scheme, and this shows the prospective purchaser a popular method of connecting the "Equator" to the bath, wash basin, and scullery sink.



Part of the interior display showing a large sectional view of a house in which the "Equator" Storage Heater is fitted.

Another window setting at the Katharine Street Showrooms, including five "Equator" Water Heaters.

It is gratifying to note how the public generally are responding to the appeal of the gas water heater, and the progress made during the past few years is excellent. This is due not only to the improved appliances available but in a large measure also to publicity efforts of this kind. As a result, consumers in ever-increasing numbers are looking to gas to provide their hot water supply. In arranging this series of displays the Croydon Gas Company give us further evidence of that spirit of progress which animates their whole selling organization.

Association of Statutory Meter Inspectors

Annual Meeting in London

The Annual General Meeting of the Association of Statutory Inspectors of Gas Meters was held in the County Hall, Westminster Bridge, on Wednesday, June 14, with Councillor J. W. Willoughby, M.B.E., J.P., in the chair.

The President opened the proceedings with a cordial welcome to the representatives of administrative authorities present, and expressed his pleasure at seeing such a representative gathering. He thought it would be expressing the feeling of the meeting by taking opportunity to congratulate Sir Cornelius Chambers, J.P., upon the recent honour bestowed upon him by the King.

Sir Cornelius, thanking the President for the kindly reference to the honour conferred upon him, said the familiar faces induced the same friendly feeling, and he was not conscious of feeling changed in any way; but it was gratifying to him that a lifetime spent in public service of one kind or another had merited recognition.

The Hon. Secretary (Mr. W. Templeton) read apologies for the absence of Mr. J. L. Sloan (Coventry) and Mr. B. T. Commander (Leicester).

The minutes of the previous annual general meeting were read and confirmed, no discussion arising.

Mr. J. L. Barry (London), Hon. Treasurer, referred to the accounts, which called, he said, for little comment, as members had previously had a copy of the balance-sheet. They had a satisfactory balance in hand, and their members numbered practically the same as for the previous year. One member had dropped out during the past year and one associate member had been admitted.

The accounts were adopted unanimously without discussion.

Report of Council.

Mr. W. Gordon (Edinburgh) read the Annual Report of the Council:

Periodical Re-Verification.—The proposal for the periodical re-verification of gas meters has occupied the attention of the Association for a considerable period, and in view of the reception given to the report last year, it was decided to make an official submission to the Board of Trade upon the lines already approved. The basis of the submission was upon conditions set up by the Institution of Gas Engineers —viz., a period of 15 years coupled with a suitable period of grace for the scheme to become fully operative. The Council is not in possession of any indication whether or not the Board intends to proceed with the necessary legislation to introduce the system, but the Council is satisfied that existing conditions justify its introduction, and that it would lead to equity, safety, and all-round efficiency.

Unstamped Meters.—The attention of the Council has been occupied over a considerable period with the failure on the part of certain gas undertakings to comply with section 13 of the Gas Regulation Act, 1920, which requires all meters that are fixed in consumer's premises, to be officially stamped. Recent information leads the Council to believe that the practice is more widespread than was formerly believed, despite the fact that during the year 1926 circular notices drawing attention to the statutory obligation were sent out by the Institution of Gas Engineers and the Board of Trade. It is desired that the details of any further evidence which may arise should be submitted to the Board of Trade and the Council acquainted of the same, when it is anticipated that action of a stronger character than in the past will be taken.

Cornering.—The Council was advised that in the instance of meters made by a certain manufacturer the method of adjustment on the tangent was such that, on the solder being run off two corners of the top panel, which permitted a wedge being driven in that corner, it was possible by means of a screwdriver to make any registration adjustment desired without interfering with the seal. Representations to the firm in question resulted in an assurance that in future the tangent pin would be securely soldered, thus preventing any further possibility of manipulation.

Sale of Gas Acts—Revision.—The following extract appears in the Final Report of the Gas Legislation Committee, set up by the Board of Trade:

Sale of Gas Acts, 1859-60.

We agree with the view expressed in the Fuel and Power Committee's Report that the interpretation of the provisions of these Acts (which deal with the testing of meters) is difficult, and it would be well, therefore, if opportunity could be found later for repealing the Acts and for setting out afresh the powers and duties of local authorities in regard to the appointment of gas meter inspectors and the establishment of meter testing stations. So far as we are aware, however, the Acts have hitherto given rise to no great difficulty in their operation.

The principal difficulty that has been brought to our notice in regard to the operation of these Acts arises from the fact that they were adoptive Acts and could be adopted only within a specified period. As a result of this Boroughs created after 1860 are precluded from setting up gas meter testing stations under the powers of these Acts. We would point out, however, that they are not precluded from securing, by private legislation, the necessary powers in this connection, a course which has, in fact, already been followed.

From the Industry's point of view the setting up of additional testing stations would probably be welcomed as a means of saving transport costs on meters in cases where undertakers have no testing station in their immediate neighbourhood. On the other hand, each additional testing station established tends to reduce the activity and income of existing stations. So far as we are aware, there has been no complaint that the number of testing stations now existing is inadequate.

We feel, all things considered, that the revision of the Sale of Gas Acts is a matter which is not, from the point of view of encouraging the development of gas supply, of sufficient importance to warrant its inclusion in immediate legislation, particularly in view of the complication, difficulty, and expenditure to which it may give rise. The question is one therefore which we feel could well be deferred until the more pressing needs of the Industry have been provided for.

Discussion

Mr. Hume (London) asked if the Hon. Secretary had received any reply concerning the memorandum sent by the Council to the Board of Trade.

Replying, the Secretary stated that no such communication had been received up to the present time.

Attention was drawn to the recent case at Birkenhead where a conviction was obtained for using a counterfeit seal. Mr. Dalton (Liverpool) gave details of how the matter arose and the course the action took.

Bailie Henderson (Glasgow) asked if it was necessary for a local authority, in a case of this kind, to obtain the consent of the Board of Trade before prosecuting, for, if so, it was a most unsatisfactory condition.

Mr. Webster (Brighton) asked if it would not be possible for the Association to make provision for undertaking prosecutions in cases where definite evidence of irregularities was available.

Mr. Watson (Sheffield) said that while there was nothing to prevent an inspector operating outside his own district, the position was not clear when the irregularities that came to notice concerned a district in which the inspector's own authority had no control.

The Secretary explained that the position in the early period of the 1920 Gas Regulation Act was that some gas engineers appeared to be of the opinion that, having been previously exempt, section 13 of the Act did not apply in their case. Following numerous instances where domestic overtures resulted in a discontinuance of the practice of fixing company sealed or unsealed meters, the knowledge that the practice was still widespread caused the Association to draw the attention of the Institution of Gas Engineers and the Board of Trade, resulting in both bodies circularizing all gas undertakings throughout the country, calling upon those undertakings to observe their statutory obligations and drawing attention to the penalties for non-observance. While the response was fairly satisfactory, there remained a number of undertakings fixing meters which were not legal measures. His attention had been drawn to Wales, in particular South Wales, although he was unable—at the moment—to offer any definite evidence. It remained, therefore, to ascertain what further steps the Association might desire to take to eliminate this illegal practice. Whereas Mr. Hume had tended to give the impression that the Board of Trade were not themselves prepared to take legal action, from what he had ascertained the Board would certainly not condone any case brought to its notice, and it had been suggested that it was desirable to submit evidence of several cases at the same time, when it was assumed the Board would be moved to take the strongest possible action.

Mr. Place (Bradford) said that in view of the explanation given by the Secretary, and the fact that little or nothing had been done since the circular of 1926, the continued

evidence of irregular practice made it desirable that a further circular be sent out which might have a salutary effect.

Mr. Place moved, and Mr. Langlands seconded, "that further representations be made to all gas undertakings upon similar lines to the circular notices of 1926."

This was carried.

Mr. Gordon said that cornering was a term used to describe the practice of lifting the corner of the top panel of a meter in order to permit a screwdriver to be inserted to manipulate the tangent of the meter which was described as being of a micrometer pattern. It was suggested that this practice was more or less confined to the locality of a particular manufacturer. The matter had previously been taken up with the manufacturer concerned, when it was understood that in future these tangents would be so soldered as to prevent the practice referred to.

Mr. Newton (Oldham) indicated that this course had not been carried into effect, and he suggested that it was necessary to go into the whole question of sealing meters in order to prevent meters being interfered with.

Mr. Pickering (Portsmouth) asked how Mr. Newton ascertained this practice was possible, whereupon Mr. Newton pointed out that it was actually carried out in his testing station upon permission being given to the firm in question to adjust the registration of a large meter. Mr. Campbell (York) said it was the duty of an inspector to seal a meter in such a manner as would prevent tampering with it.

Mr. Gordon said that perhaps it would meet the case if the Council took the matter up with the firm concerned. Mr. Newton, in reply, said he still considered such a course would be unsatisfactory, and that the whole question of the sealing of meters to prevent manipulation should be gone into.

Mr. Rolfe (L.C.C.) moved, and Mr. Buttle (Norwich) seconded, the adoption of the Council's Report.

Mr. Watson said he would like to urge upon the Board of Trade the dire need for amending the Sale of Gas Acts and Regulations. He did not agree with Mr. Hume that the Report of the Gas Legislation Committee—so far as it related to the Sale of Gas Acts—torpedoed the efforts of the Association, and he would not recommend sitting down to it. There was distinct ambiguity, and there was doubt in dealing with the areas outside the particular district for which an Inspector was appointed.

Mr. Foster (Exeter) said he associated himself with Mr. Watson's remarks and he would second the motion, whereupon it was resolved that the Council be instructed to proceed without undue delay to urge upon the Board of Trade the necessity for early revision and co-ordination of the Gas Measures Acts, and that opportunity be taken to recall all the various points that had previously been referred for consideration by the Association.

Election of Officers.

President.—Councillor J. W. Willoughby, M.B.E., J.P. (Salford).

Vice-Presidents.—Sir Cornelius Chambers, J.P. (Birmingham), Councillor W. O. Wills (Exeter), J. Farrar, J.P. (Leeds), Bailie J. Henderson, J.P. (Glasgow), Bailie Adams (Edinburgh), Councillor Wheelhouse (Hull), and H. J. C. Davies (Chief Officer, Public Control Department, L.C.C.).

Hon. Secretary.—W. Templeton (Leeds).

Hon. Treasurer.—J. L. Barry (L.C.C.).

Council.—W. Gordon (Edinburgh), G. Hume (City of London), G. F. J. Knott (L.C.C.), A. Winterbottom (Manchester), F. Colburn (Birmingham), E. M. Foster (Exeter), and J. E. Sloan (Coventry).

Auditors.—F. A. Rolfe (L.C.C.) and E. Simpson (Salford).

In response to the cordial invitation from the Corporation of the City of Exeter, it was resolved that the next annual general meeting be held in Exeter.

Retirement of Mr. Barrow.

The retirement of Mr. H. N. Barrow from the list of Vice-Presidents was the occasion of a suggestion that it would not be fitting to let the opportunity pass for expressing the deep and grateful appreciation of this Association for the generous and zealous services which he had in the past rendered. This expression met with unanimous approval, and the Secretary was directed to convey the terms of the following resolution:

> Resolved that this Association deeply regrets the retirement of Mr. H. N. Barrow from active participation in its affairs, and desires to place upon record the grateful appreciation of the untiring services he has rendered in his capacity as President for so many years in the past.

Visit to Watson House.

The afternoon session was devoted to a visit to Watson House, where, by the generous hospitality of the Governor and Directors of the Gas Light and Coke Company, the visitors were entertained at lunch and tea.

Responding to the toast moved by Mr. J. W. Willoughby, President of the Association, Mr. Stephen Lacey, on behalf of the Company, said that at Watson House they had a link in common with the Association of Statutory Inspectors of Gas Meters—that of testing. The visitors could not fail to be impressed by the work and experiments carried out, the infinite variety and detail, the youth and enthusiasm of the staff. Everyone appeared to be most impressed by the wonderful scheme of training facilities, and the unique exhibition of splendid work executed by the apprentices under training.

PARLIAMENTARY INTELLIGENCE

[From Our Special Correspondents.]

House of Lords.

Private Bills.

The Commercial Gas Bill and the Gas Light and Coke Company's Bill have been read a second time, and are now awaiting the appointment of a Select Committee to consider them.

The South Metropolitan Gas Bill will be considered by the Committee on Unopposed Bills on Thursday.

Special Orders.

Special Orders on the application of the Borough of Neath, and the Herne Bay Gas Company, Ltd., have been laid before the House and referred to the Special Orders Committee.

The following Gas Orders have been passed by the Special Orders Committee and are awaiting the affirmative resolution of the House: Northampton; Ashburton; Hastings and St. Leonards (with modifications).

House of Commons.

Private Bills.

The East Hull Gas Bill has been read a second time and committed.

Special Orders.

The following Special Orders have been presented and ordered to lie upon the Table: Herne Bay Gas Company, Ltd., and Borough of Neath.

Gas Legislation.

Mr. Lewis asked the President of the Board of Trade whether, in view of the taxation of fuel oil, it was proposed to introduce legislation to enable the Gas Industry to supply gas at special rates to large consumers for power purposes.

The Parliamentary Secretary to the Board of Trade (Dr. Burgin) said that in an Interim Report dated Dec. 5, 1932, the Departmental Committee appointed to advise on the amendment of existing Gas Legislation recommended certain changes in the law governing methods of charge by statutory gas undertakers. These recommendations, together with those in the Committee's Final Report dated March 24, 1933, were at present under consideration.

Mr. Lewis then asked if it would not have been better to have made gas cheaper before making fuel oil dearer, and Mr. Thorne pointed out that private gas undertakings as well as local authorities who had charge of gas-works had power now to sell gas on a sliding scale of prices, more especially where gas engines were used.

XUM

THE "JOURNAL" TECHNICAL RECORD

Which contains Reports of Meetings of Gas and Allied Associations

The Flow of Gas in Pipes*

By W. E. BENTON, M.Sc., Chief Chemist, Cannon Iron Foundries, Ltd.

The flow of fluids in pipes has been the subject of study for upwards of a hundred years. Gradually certain empirical laws have been discovered, the earliest formulæ of Pole and Chezy have been corrected or amplified by the later discoveries of Unwin, Stanton, Pannell, Lee, and others, and in quite recent years very careful experiments and calculations have been made by Lacey† to meet the special requirements of the Gas Industry.

Now, although it is possible from the formulæ provided by these researches to calculate with some accuracy the resistance to flow offered by a pipe of almost any size and shape, it is less simple to understand why the pipe should offer that resistance, and to picture the actual motion of the gas. Only in the case of viscous flow are we at all sure that we understand what happens inside the pipe. There are indeed many who work happily with the machinery of empirical equations with no question as to their meaning; but there are also others who (like myself) demand a picture, some sort of theoretical basis, however slender, before they trust their fortunes to the working of an algebraical "mill." The picture which I have constructed, as it were to satisfy my own conscience, is the subject of this paper. Should it seem incongruous to you that a gas appliance maker should speak on a subject so peculiarly the province of the gas engineer, I would ask you to remember that we ourselves use pipes, only a few inches long, it is true, and operated by pressures measured in hundredths of an inch, but the general laws which govern the flow of gas along a main a mile in length also control the movement of air and gas in a gas fire burner.

Energy and Momentum.

A body of gas under pressure is said to have potential energy, which can be converted into kinetic energy, or energy of motion, when that pressure is released. The relation is a simple one. The actual excess pressure p (in poundals per sq. ft.) is the potential energy of each unit volume (1 c.ft.), and when this results on release in a velocity v (in ft. per sec.) we have:

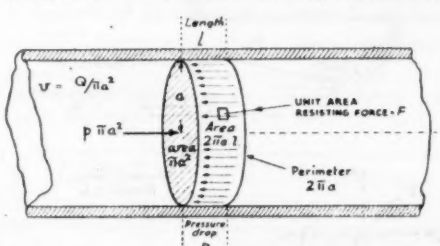
$$p = \tfrac{1}{2}\rho v^2$$

where ρ is the absolute density (in lbs. per c.ft.), or the mass per unit volume. Similarly when we retard a body of moving gas, some of the kinetic energy is re-converted into potential energy. If, however, without actually reducing the velocity we change the direction of flow, another property is affected—namely, the momentum. Sometimes described as the amount of motion of a body, momentum is the product of mass and velocity, in the case of a gas ρv per unit volume. Unlike potential energy, which has no direction, momentum is a vector, having both size and direction. Force is required to change the direction of momentum, and if this force has a component in the direction of motion, work must be done to effect the change. The more quickly the change is made the greater will be the required force, or alternatively, when a gas is compelled to change its momentum, it exerts a reaction equal to the rate of change of momentum. Thus a sharp bend in a service has a greater resistance than a more gradual bend, and (to take another instance) heating engineers employ the reaction exerted on the wall of a bend to obtain circulation in a radiator connected at that point.

A straight parallel pipe imposes one condition upon the flow of gas which must be obeyed, no matter whether the motion be streamline or turbulent. This is the condition of continuity: "In unit time the same quantity of fluid must pass through every cross-section." We will neglect small differences due to compression, and speak only of low-pressure flow. Thus if a be the radius of the pipe, and Q the rate of flow in c.ft. per second, there will be a mean velocity v, given by:

$$v = \frac{Q}{\pi a^2}$$

In the centre the velocity may be as great as $2v$, and at the sides the fluid may be practically at rest, but the net effect of the whole flow will be a mean linear velocity of v ft. per second. Since the mean velocity is maintained at a constant value, the mean momentum must also be constant. Any momentary loss of momentum must be immediately made good from some source of energy, and since the only source of this kind is the potential energy or excess pressure of the gas, we may say that the velocity and momentum are maintained at the expense of a steady diminution of pressure. The resisting forces present in the pipe tending to change the momentum may act between different parts of the gas itself, or between the gas and the wall of the pipe, but ultimately all the forces must be carried by the pipe. If one holds a telescope vertically and allows it to extend, there are certainly frictional forces between the different tubes, but throughout the movement all these forces add up to an amount rather less than the total weight of the tubes, which is the gravitational force felt by the supporting hand. If the resultant dragging force on each unit area of pipe surface be F poundals per sq. ft., the total dragging force on the wall of a pipe of length l ft. will be $F2\pi al$. Since there is no resulting acceleration, this will be exactly balanced by the force acting over the two ends of the pipe tending to maintain the motion—namely, $p\pi a^2$, where p is the fall in pressure over the length l. Hence we have an equation of forces:



Balance of Forces: $p\pi a^2 = 2\pi a . l . F$

$$\frac{p}{l} = \frac{2}{a} . F$$

Fig. 1.

Force maintaining motion = Total dragging force on pipe surface (fig. 1).

$$p . \pi a^2 = F . 2\pi a\, l$$

$$\text{or} \quad \frac{p}{l} = \frac{2}{a} . F$$

or, in differential notation,

pressure gradient,

$$\frac{dp}{dl} = \frac{2}{a} . F$$

We will now examine the nature of the dragging force F, and show how it is affected when a gas passes from streamline motion to turbulent flow.

Streamline or Viscous Flow.

It is common knowledge that within a certain limiting condition, the nature of which we will examine presently, the motion of a fluid is "streamline"—*i.e.*, every particle

* Paper before the Yorkshire Junior Gas Association, May 20, 1933.

† "GAS JOURNAL," July 4, 1923.

appears to pursue a smooth undeviating path parallel to the axis of the pipe. A filament of coloured liquid introduced into a glass tube through which water is flowing is seen to remain undisturbed, and will travel down the tube with only the very slightest tendency to mix with the neighbouring filaments of water (fig. 2). As the conditions

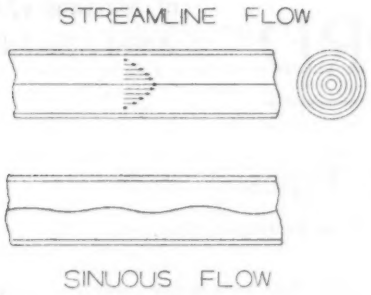


Fig. 2.

of velocity, viscosity, or density are varied a limit can be approached, shown by the appearance of sinuous waves in the coloured filament, beyond which the filament appears to break-up into a jumble of broken threads that rapidly mix with and colour all the contents of the tube. The extreme orderliness of streamline flow is one of the very rare instances of Nature behaving in a perfectly simple manner.

The kinetic theory teaches us that every pure gas is composed of molecules of a definite size and mass, moving with immense speeds, and continually colliding with and rebounding from one another. No energy is lost in these collisions, the molecules rebounding after the manner of perfectly elastic spheres. In a volume of oxygen at N.T.P. these collisions occur 5000 million times a second. The mean velocity of an oxygen molecule at N.T.P. is 42,500 cm./sec., and therefore, the mean distance which it travels before colliding with another is only about 10 millionths of a cm. This distance is known as the mean free path of the molecule. In hydrogen the molecules move at 170,000 cm. a second, and travel on the average 18 millionths of a cm. between collisions.

Now what part does this incessant molecular agitation play in the phenomena of fluid friction? Consider a tiny portion of the moving gas, and imagine that this is made up of parallel sheets, of thickness equal to the mean free path, L. Picture to yourself two neighbouring sheets, and assume that one is moving parallel to itself at a rate v faster than the other (fig. 3). The molecules in the sheets

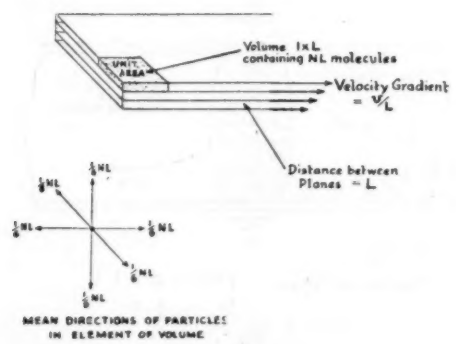

Volume 1xL containing NL molecules
UNIT AREA
Velocity Gradient = V/L
Distance between Planes = L
⅙NL
MEAN DIRECTIONS OF PARTICLES IN ELEMENT OF VOLUME

Fig. 3.

are moving in every possible direction, so that on the average at any moment one sixth are moving towards the other sheet. Now all these particles are able to reach the other sheet, as its centre line is distant from that of the other only the length of their mean free path. The mean time taken to reach the other plane is $\frac{L}{v}$. If there are N molecules per unit volume, the number leaving unit area of either plane at any moment is $\frac{1}{6}$ NL, and if m be the mass of each molecule, the forward momentum carried across from the fast to the slow plane in time $\frac{L}{v}$ is $\frac{1}{6}$ NLmv. At the collision the direction of the momentum will be reversed. Hence the rate of loss of momentum by the fast plane, and the rate of gain of momentum by the slow plane

$$= \tfrac{1}{3}\,\mathrm{N}mv^2.$$

Since Nm, the total mass per unit volume, is equal to the density ρ,

$$\tfrac{1}{3}\,\mathrm{N}mv^2 = \tfrac{1}{3}\rho v^2.$$

Now the rate of change of momentum is equal to the force acting on unit area of either plane. We have assumed a change of velocity v in a distance L—*i.e.*, a velocity gradient of $\frac{v}{L}$. Hence the force on either of two planes of unit area unit distance apart in a field of unit velocity gradient is

$$\tfrac{1}{3}\rho\mathrm{VL}.$$

But this expression also defines the property which we call the viscosity, η, of the fluid.

$$\text{Hence } \eta = \tfrac{1}{3}\rho\mathrm{VL}.$$

The discovery of this relationship is due, I believe, to the genius of Clerk Maxwell, and created a great sensation when first announced. Since then the values of molecular velocities and mean free paths have been obtained independently by widely different methods, and the results have only confirmed the truth of this equation. We can now think of viscosity as a property of fluids arising from the interchange of molecular momentum, somewhat similar to the effect of throwing bricks from a fast goods train into the trucks of one moving more slowly in the same direction. Maxwell's equation requires that neighbouring portions of fluid should be moving forward uniformly in the same direction. This would appear to indicate that this kind of friction occurs when the motion is orderly or "streamline." When flowing through a pipe in this manner the gas may be assumed to travel in a series of thin co-axial sleeves, the outermost being actually stationary, and the greatest velocity being in the centre. Each imaginary sleeve is always losing momentum to its outer neighbour and gaining momentum from those inside. Since no sleeve, on balance, either gains or loses momentum, any instantaneous loss in momentum, due to the sleeve losing more than it receives, must be immediately made good from its potential energy. Thus the pressure difference acting between the ends of the sleeve represents the net rate of loss in molecular interchange of momentum. Although the reasoning involves so-called "calculus" methods, it is easy to show in this way that the motion will settle down into a condition such that the velocity of any sleeve is proportional to the difference between the cross-sectional area of the whole pipe and the cross-sectional area of the tube formed by the sleeve. The velocity is a maximum at the centre, and zero at the sides of the tube. If the mean velocity $v = \mathrm{Q}/\pi a^2$, the velocity at the centre is $2v$. Since the velocity falls from $2v$ at the centre to zero at the sides, the mean velocity gradient is $\frac{2v}{a}$. This is not uniform across the pipe, however, but increases steadily from zero at the centre to $\frac{4v}{a}$ at the sides.

We have seen that ultimately all the forces on the fluid must be borne by the walls of the pipe, and that if F be the dragging force per unit area of pipe surface

$$\frac{p}{l} = \frac{2}{a} \cdot \mathrm{F}$$

Now F is due to a velocity-gradient at the walls of $\frac{4v}{a}$ in a gas of viscosity η.

$$\therefore \mathrm{F} = \eta \cdot \frac{4v}{a}$$

$$\frac{p}{l} = \frac{2}{a} \cdot \eta \cdot \frac{4v}{a} = \frac{8v\eta}{a^2} = \frac{8\mathrm{Q}\eta}{\pi a^4}$$

$$\text{or } \mathrm{Q} = \frac{p\pi a^4}{8l\eta},$$

which is Poiseuille's Formula for Viscous Flow.

Turbulent Flow.

The evidence of the coloured filament in a tube of water leaves us no room to doubt that beyond a certain limiting condition the gas will pass from streamline motion into a state which, for want of a better name, has been called turbulent flow. If we plot the loss of pressure against the total flow we have at low velocities a straight line passing through the origin (fig. 4)—*i.e.*, the loss of pressure over a certain length of pipe is directly proportional to the rate of flow. At a certain point the gradient breaks and becomes steeper, the line being no longer straight but curved. Investigation shows that the pressure loss is now approximately proportional to the square of the velocity. Since we are in ignorance as to the nature of this new type of resistance we are compelled to fall back on "reasonable

guessing," the basis of all scientific research. The fact that the pressure loss now depends on the square of the velocity should give us a clue. The relation

$$\frac{p}{l} = \frac{2}{a} \cdot F$$

is true of both viscous and turbulent motion, as it rests on no assumption as to the nature of the resistance. It is reasonable to think that the resistance still depends in

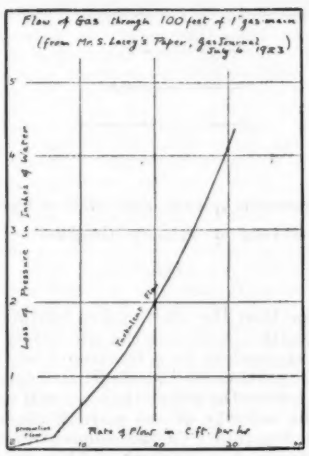

Flow of Gas through 100 feet of 1" gas main
(from Mr. S. Lacey's Paper, Gas Journal, July 6 1932)
Loss of Pressure in Inches of Water
Transition Flow
Rate of Flow in C.ft. per hr

Fig. 4.

some way on the rate of loss of momentum. Now on the average each unit volume of gas has a forward momentum ρv, and in unit time v volumes of gas (on the average) pass through each unit area of cross-section. Therefore the average rate of flow of momentum through unit area of cross-section is ρv^2. We might assume tentatively that in turbulent flow F, the resisting force per unit area of pipe surface, is equal to a certain fraction of ρv^2 Now, strange though it may appear, water and gas engineers generally have used $\frac{1}{2}\rho v^2$ instead of ρv^2 in this relation. The reason is that they obtained the empirical formula first, and working backwards arrived at the simple equation underlying it; but in doing this they tacitly assumed that $\frac{1}{2}\rho v^2$, the kinetic energy per unit volume, was of more significance than ρv^2, the rate of flow of momentum per unit area. The choice does not affect the working of the equation, as it simply alters the value of the fraction introduced; but it decidedly affects the success of any attempt to explain its meaning. Following ordinary practice, therefore, we will asume that F is a certain fraction ζ of $\frac{1}{2}\rho v^2$—*i.e.*,

$$F = \zeta \cdot \tfrac{1}{2}\rho v^2$$

$$\therefore \frac{p}{l} = \frac{2}{a} \cdot F$$

$$= \frac{2}{a} \cdot \zeta \cdot \tfrac{1}{2}\rho v^2$$

$$= \frac{\zeta}{a} \cdot \rho \frac{Q^2}{\pi^2 a^4}$$

$$\text{or } Q = \pi a^2 \sqrt{\frac{ap}{\zeta \rho l}}$$

which is Unwin's form of Chezy's Formula, shorn of its numerical constant.

If we substitute $\zeta = 0{\cdot}0065$ or $\frac{1}{154}$, we have Pole's formula, which has been used for many years as an approximate means of estimating the capacity of a given service. The fraction ζ has no physical dimensions, and Pole as a result of experiment assumed it to be constant at about $0{\cdot}0065$ or $\frac{1}{154}$.

By giving ζ an appropriate value we can represent viscous flow as a special case of the more general law of turbulent flow. The condition is:

$$\eta \cdot \frac{4v}{a} = F = \zeta \cdot \tfrac{1}{2}\rho v^2$$

$$i.e., \zeta = \frac{\eta \frac{4v}{a}}{\frac{1}{2}\rho v^2} = \frac{8\eta}{\rho v a} = \frac{16}{\left(\frac{vd\rho}{\eta}\right)}$$

where d = the diameter $= 2a$.

Thus, whereas in turbulent flow ζ is approximately constant, in viscous flow it varies inversely as $\left(\frac{vd\rho}{\eta}\right)$. This peculiar quantity, known usually as Reynold's Parameter, is of immense importance in the study of fluids, and a few words as to its nature may not be out of place.

It is easy to show that $\left(\frac{vd\rho}{\eta}\right)$ has no physical nature. It is not a length, area, force, momentum, or anything other than a simple number. It does not even depend on the system of units employed, provided that that is consistent throughout. Thus whether we calculate $\left(\frac{vd\rho}{\eta}\right)$ in lb.-second-ft., or grammes-second-cm., the result is the same. Further, it can be shown that when two fluids, whether liquids or gases, have the same value of $\left(\frac{vd\rho}{\eta}\right)$ they will behave in somewhat similar ways—that is, they will either both be in viscous flow, or both in turbulent flow. There is a critical value of $\left(\frac{vd\rho}{\eta}\right)$ when every fluid will pass from viscous to turbulent flow, and *vice versa*. Reynolds found this to be approximately 2320. Therefore, when viscous flow becomes turbulent $\left(16 \Big/ \frac{vd\rho}{\eta}\right)$ is arrested at the constant value $\frac{16}{2320}$ or $\frac{1}{145}$. This is very close to Pole's $\frac{1}{154}$, which he judged to be the value of ζ throughout turbulent flow. On this basis the relation between ζ and $\left(\frac{vd\rho}{\eta}\right)$ would be as shown in fig. 5. The value of ζ would fall hyperbolically until $\left(\frac{vd\rho}{\eta}\right) = 2320$, when it would suddenly become constant at about $0{\cdot}0065$.

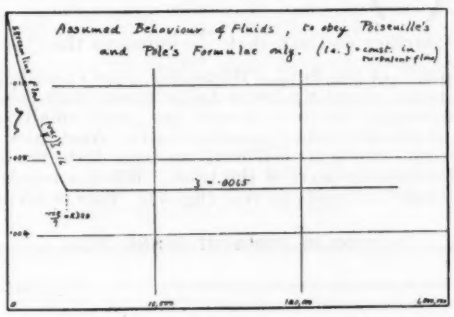

Assumed Behaviour of Fluids, to obey Poiseuille's
and Pole's Formulae only. (i.e.) = const. in turbulent flow
Stream Line Flow
ζ = ·0065

Fig. 5.

It was soon found that this simple relation required amendment. Very elaborate measurements by Stanton and Pannell, using drawn brass tubes, confirmed later by Lacey for town gas in gas pipes of small diameter, showed that ζ in turbulent flow follows a smooth gradual curve, falling as $\left(\frac{vd\rho}{\eta}\right)$ increases. At the transition from viscous to turbulent flow ζ appears to jump from the one curve to the other, measurements in this region being extremely difficult to make with accuracy (fig. 6).

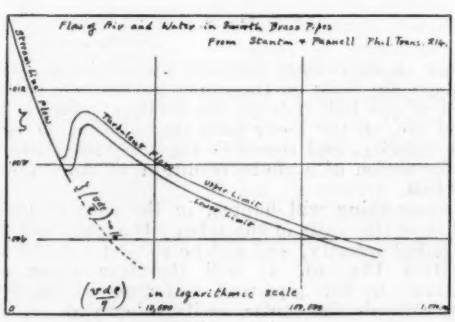

Flow of Air and Water in Smooth Brass Pipes
From Stanton & Pannell Phil. Trans. 214.
Stream Line Flow
Turbulent Flow
upper limit
lower limit
(vdρ/η) in logarithmic scale

Fig. 6.

Many formulæ have been put forward to represent the variation of ζ with increase of $\left(\frac{vd\rho}{\eta}\right)$. The variation is slow, otherwise Pole's simple formula would never have been used so long. None of these empirical attempts have any basis in theory, so that their only value is in enabling one to calculate ζ to some degree of accuracy, instead of obtaining it from the graph of $\left(\frac{vd\rho}{\eta}\right)$ and ζ.

The Nature of Turbulent Flow.

My following remarks I wish you to regard purely as speculation. They are offered in the hope that they will

throw some light, however inadequate, on the nature of turbulent flow. If experimental evidence in support be lacking, we may console ourselves with Fourier's famous dictum, " A theory can be useful without being true."

First of all, it is instructive to build up a formula on the basis of an assumption, and see whether it is possible to obtain Unwin's formula. We find that the formula is *not* obtained if we assume:

(1) That each unit volume of fluid loses a certain fraction of its momentum
  (*a*) per unit length of tube,
  (*b*) per unit time per unit length,
  (*c*) per unit area of surface per unit time.

(2) That each unit volume of fluid loses a certain fraction of its kinetic energy
  (*a*) per unit length,
  (*b*) per unit area.

There are very many other variations of these assumptions, none of which give Unwin's formula. The only theoretical picture which I have found at all satisfactory is the following:

We have seen that $\left(\frac{vd\rho}{\eta}\right)$ can be written $8\left(\frac{\rho v^2}{\eta\frac{4v}{a}}\right)$—*i.e.*, eight times the flow of momentum per unit area divided by the dragging force per unit area of pipe surface. This indicates the existence of a form of couple, tending to rotate the portions of fluid near the walls of the pipe. The ratio $8\left(\frac{\rho v^2}{\eta\frac{4v}{a}}\right)$ may be compared to a ratio of forces. We may go further and say that $\frac{vd\rho}{\eta}$ indicates the " degree of constraint " of the fluid. When this ratio exceeds a limiting number, which we know to be about 2320, the hypothetical couple becomes a real one, and small rotating bodies of gas are formed near the walls. Now these eddies, as we may call them, will have an immediate tendency to move towards the axis of the tube. When a tennis ball is " under-cut " it tends to rise (fig. 7). This is because the

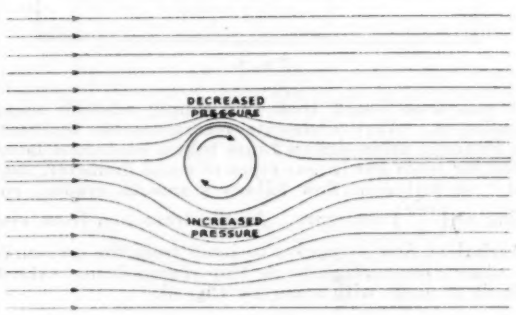
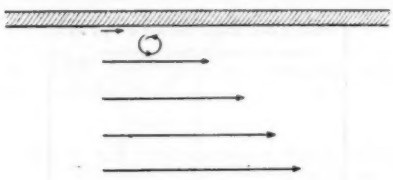


Fig. 7.

resistance to its passage through the air is greater below than above the ball; on the upper part of the surface the rotation of the ball reduces the relative velocity between ball and air, on the lower part the rotation increases the relative velocity, and therefore the resistance. The result is the formation of a slight resultant pressure tending to lift the ball.

The same thing will happen in the case of the eddies formed near the walls of the tube. The eddy will have no initial radial velocity, and will be subject only to a radial acceleration (fig. 8). It will therefore move at first tangentially to the pipe-wall and then gradually move inwards towards the centre as its velocity down the pipe increases. These tiny eddies will be formed at very many points on the pipe surface, possibly according to some logical arrangement of which we have no knowledge. We can only guess at the form of their path, and since a number of eddies may be formed at the circumference of the same cross-section, or disc of pipe, their paths will sweep out an envelope or shell, before they intersect at the centre-line. Now this shell will have a certain thickness, depending on the size of the eddy, and as a first approximation we will assume that the eddy does not grow in size, and that therefore the imaginary shell is of uniform thickness. At any point on the shell the eddy will have the same forward velocity as that of the fluid about it. The fluid in the shell is therefore the actual fluid whose momentum is interfered with by the formation of these eddies at the strip of surface on the wall where the shell makes contact. It should again be noted that the shell has no real existence but is purely an envelope of eddy paths. We have no evidence as to its shape, but we can assume provisionally that the area of its surface is a multiple m of its base area πa^2, where m may be a function of v, a, ρ, and η. [If the shell were a hemisphere, its surface would be $2\pi a^2$, and m would therefore be 2, and if it were a cone of base angle α, its surface would be $\pi a^2 \sec \alpha$, and m would therefore be $\sec \alpha$.]



Formation of Eddy near Wall of Pipe in Field of Velocity Gradient.

Fig. 8.

Let us assume that the shell makes contact with the pipe over a short length l and that the whole loss of momentum in the shell is equivalent to a fraction k of the momentum of this contact portion of the shell, embracing in this assumption another to the effect that we will use v, the mean velocity, for the velocity of any part of the shell. We can imagine that a fraction k of the momentum of the strip of shell of area $2\pi a\ l$ is lost when the eddies are formed in it.

The fraction of momentum lost $=$

$$\frac{2\pi a l \,.\, k}{\pi a^2 m} = \frac{2l}{a} \cdot \frac{k}{m}$$

The rate of flow of momentum through the short length $l =$ $\rho v^2 \,.\, \pi a^2$.

Of this a fraction $\frac{2l}{a} \cdot \frac{k}{m}$ is lost.

$$\text{Rate of loss of momentum} = 2\pi a \,.\, l \,.\, \frac{k}{m} \,.\, \rho v^2$$

$$\text{But rate of loss of momentum} = \text{maintaining force.}$$

$$\therefore\ p \,.\, \pi a^2 = 2\pi a \,.\, \frac{k}{m} \,.\, l \,.\, \rho v^2$$

$$\text{or } \frac{p}{l} = \frac{2}{a} \cdot \frac{k}{m} \,.\, \rho v^2$$

With the exception that we have used ρv^2 instead of $\frac{1}{2}\rho v^2$, this equation is the same as Pole's formula for turbulent flow. $\frac{k}{m}$ is therefore equivalent to ζ (where ζ is calculated on rate of flow of momentum, instead of kinetic energy). From this conception of eddy-shells we therefore find that ζ is possibly the ratio of the fraction of momentum lost in the formation of the eddy to the " expansion " (to borrow a word) of the eddy shell. Since to a first approximation ζ is a constant, $\frac{k}{m}$ is also approximately constant. This method of attack opens up very interesting avenues of speculation, of which, however, we have no time to treat here. I put it forward as the only theoretical picture, however crude and incomplete, which I have found to satisfy the experimental formula. It has been said of some of the classical equations of hydrodynamics that they are " more true than useful." It is possible that this picture of eddy-shells is " more useful than true." If we are unable to combine these two excellent virtues in equal proportions in our philosophy, I leave it to you to decide which extreme is to be preferred.

Discussion.

The PRESIDENT (Mr. J. W. Wood) said that he was sure that the excellent paper would have shown to many of them the connection between various properties which hitherto they had probably regarded as totally distinct and quite separate one from another. He wondered whether he was in order in asking Mr. Benton whether the stable conditions presupposed in the treatment of long pipes really held good in the case of the very short tubes used in gas fire burners, to which the author had referred. In nearly all the appliances with which they were concerned, where the burners were of the bunsen type, the pipes were very short and the changes in cross-section frequently very abrupt. The energy leaving the burner appeared often to be a very small fraction of that entering it. He would like to know whether Mr. Benton would give them any figure for the mechanical efficiency of the ordinary injector. Various people had worked it out on a purely theoretical basis, and it certainly looked as if they ought to be able to entrain a great deal more air than was found in practice. Either the burner design was wrong or the basis of calculation was at fault. If they could only hit upon the right method of solving the

problem there was a good margin for improvement. Mr. Benton appeared to understand both the practical and the theoretical sides of the subject.

Mr. BENTON said he was quite willing to discuss the design of atmospheric gas burners. The common mistake made was to work out an "efficiency" on the basis of energy. When a bullet was fired into a suspended wooden block, the block with the bullet embedded in it would move off with a certain velocity; and on comparing the kinetic energy before and after the impact they would find a definite loss. This loss of energy was expressed in the heat produced in the block of wood. But if they calculated the momentum before and after, they would find very little change. Similarly, when gas entrained air some energy was converted into heat, but under favourable conditions much of the momentum was conserved. The air and gas mixture had then to traverse the mixing-tube, and be distributed to the row of teat orifices. The latter should not be classed as true resistances, as they caused very little loss of energy. The mixing-tube with the subsequent bend were necessary to produce a well mixed body of air and gas, having a much reduced velocity. Distribution to the orifices must be so far as possible by pressure, not by velocity.

Another point was of considerable interest in this connection. An appliance which worked satisfactorily on 450-gas was usually unsuitable for 560-gas, at the same pressure. For the same B.Th.U. rate they would use less gas of 560 calorific value than of 450-gas. This would enable the injector orifice to be reduced and should help the aeration. Also the density would be lower. This should again reduce the orifice and assist the aeration. But against this one must offset the lowered entraining power due to the lower density, and in practice this disadvantage was found more than to outweigh the advantages of smaller quantity and lower density. In round figures, a burner giving an aeration of 2·5 air/gas on 450-gas at 25 tenths, would require 30 tenths to give the same aeration on 560-gas, assuming efficient means of adjustment.

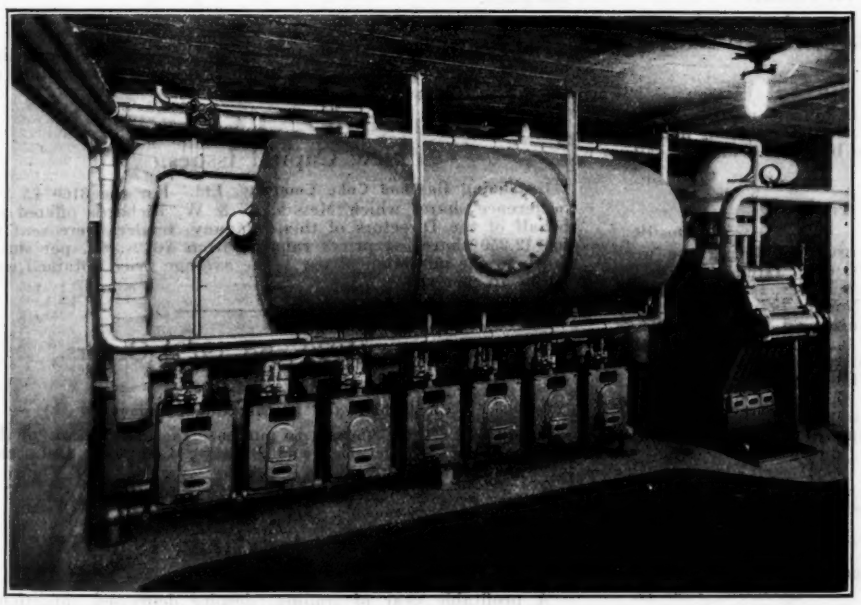
Mr. H. HODGSON (Leeds) said that Mr. Benton had assumed that in streamline flow the gas moved in concentric sleeves. At the centre the velocity was twice the mean velocity. At what distance from the centre would the velocity be equal to the mean velocity, and would not this be the proper position for a Pitot tube? The speaker referred to experience with a Pitot tube, when small alterations in its position showed apparent changes in velocity.

Mr. BENTON said that it was usually assumed that, wherever a Pitot tube was required, turbulent flow could be assumed, and therefore as a mean reading the tube would record the true mean velocity of flow. The National Physical Laboratory had published some information as to the best method of positioning the instrument. Streamline flow was contained within such a narrow limiting condition that it seldom appeared in practical problems. In turbulent flow the instantaneous velocity at any point, of course, varied very widely, but the mean velocity at any point, which was what was really recorded by the Pitot tube, was not quite constant over the cross-section. Mr. C. A. Masterman, of the Gas Light and Coke Company, from observations of heat losses from geyser flues, had shown that very probably there was a dead layer of gas close to the wall of the pipe, and that this was disturbed when the gas went round the bend.

Mr. H. J. HODSMAN (Leeds University) said that he thought one need only consider turbulent flow when using Pitot tubes. He had listened to the discussion of the point with very great interest. Referring to the subject of the paper, Mr. Lacey had set out in very great detail the formulæ for calculating capacities of services, and it was not very difficult to make these calculations. He must confess, however, that in the process of teaching this subject he had often found himself using these equations without feeling quite satisfied in his own mind as to what they meant, and therefore the exposition which Mr. Benton had given them had been exceptionally valuable. He had been listening for what Mr. Benton would say about the break down from streamline to turbulent flow, because he always found it difficult to account for that peculiar change in the pressure-gradient. His own impression was that during the change-over there was a condition of instability, during which the gas obeyed neither the one law nor the other. Would the author say something about that point?

Mr. BENTON, in thanking Mr. Hodsman for his comments on the paper, said that he also was doubtful how to interpret the change-over from streamline flow to turbulence. Many writers on the subject had said that since the loss of pressure varied as the first power of the velocity in viscous flow, and as the second power in turbulent flow, there might be intermediate stages where the flow varied to the power of 1·3, 1·5, 1·7, &c. With all respect to this opinion, he could not agree that this was probable. In his opinion, "Nature did not work in fractional indices." It might be illogical to say that Nature did not work in ways which they could not understand, but there appeared to be every probability that Nature's methods were more often simple than complex. Mr. Benton explained that it was possible that viscous flow did not come to a sudden end, but died out gradually as the number of eddies increased. He had worked out a formula which fitted the curve, including the change-over, remarkably well, but, after all, this was only following the empirical methods favoured by civil engineers and others, and had little theoretical significance.

GAS-FIRED EQUIPMENT FOR SPORTS PAVILIONS, INSTITUTIONS, &c.



An example of the high-efficiency Apparatus installed for hot water equipment in the Dressing Rooms of the Sports Club at the White City Stadium, Wood Lane, Shepherd's Bush.

Boiler Plant in the new Dressing Rooms for the Athletic and Football Meetings, comprising a battery of three No. 2 "EMPIRE" Boilers and a battery of four ditto, for the bathing pools and shower and lavatory basins respectively, while the R.7 "VICTOR" Boiler (capacity 170,000 B.Th.U.) is installed for warming this building with Low-Pressure Hot Water.

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GAS MARKETS & MANUFACTURES

Stock Market Report.

[For Stock and Share List, see later page.]

The new Account commenced on the Stock Exchange last week with quiet conditions in all markets. The opening speeches at the World Economic Conference, although well received in the City, had little effect on business. The turning point was reached after Mr. Chamberlain's statement on the War Debt negotiations with President Roosevelt, and on Thursday British Government and other investment stocks opened strongly. This improvement, however, was subsequently checked by profit-taking, and on Saturday markets became dull again, though the general undertone was steady.

Conditions in the Gas Market remained unchanged. The volume of business was normal, and prices of recorded transactions were in the main either comparable with or a trifle above those of the previous week, but quotations generally remained unaffected. The only two improvements occurred in North Middlesex 6% consolidated with a gain of 3 points to 140, and, on the Bristol Exchange, Newport (Mon.) 5% maximum stock rose 1 point to 101½. Apart from the usual *ex* interest reductions at this time of the year, falls took place in Imperial Continental ordinary with a drop of 3 points to 207; South Metropolitan ordinary and 5% debenture declined 1 and 1½ points respectively; and, at the local Exchange, Newcastle 4% preference was fractionally lower at par.

In continuation of its policy, the South-Eastern Gas Corporation's latest proposal is an offer to purchase the capital of the Sheppy Gas Company, as noticed on an earlier page. Since December last the Corporation has obtained control of nine companies—viz., Dover, Deal, Folkestone, Maidstone, Tunbridge Wells, Whitstable, Rochester, and Sittingbourne, and power has now been obtained to double the then issued capital of £500,000 £1 ordinary shares and £500,000 £1 4½% preference shares to provide funds for further expansion. The ordinary shares, which were issued at 24s., can now be purchased at round about 26s., and the preference shares at 21s. 9d.

Current Sales of Gas Products.

The London Market for Tar Products.

LONDON, *June* 19.

The prices of tar products in the London market continue at about the following levels:

Pitch, 80s. per ton f.o.b.

Creosote, 3d. per gallon.

Refined tar, 4d. to 4¼d. per gallon in bulk at makers' works.

Pure toluole, 2s. 4d.; pure benzole, 1s. 9d.; solvent naphtha, 95/160, 1s. 7d.; and 90/140 pyridine bases, 4s.—all per gallon naked at makers' works.

Tar Products in the Provinces.

June 19.

The average prices of gas-works products during the week were: Gas-works tar, 32s. 6d. to 37s. 6d. Pitch—East Coast, 80s. to 82s. 6d. f.o.b. West Coast—Manchester, Liverpool, Clyde, 80s. to 82s. 6d.* Toluole, naked, North, 1s. 9d. to 1s. 10d. Coal-tar crude naphtha, in bulk, North, 6d. to 6½d. Solvent naphtha, naked, North, 1s. 4d. to 1s. 5d. Heavy naphtha, North, 10d. to 11d. Creosote, *ex* works, in bulk, North, liquid and salty, 2d. to 2½d.; low gravity, 1½d.; Scotland, 2d. to 2½d. Heavy oils, in bulk, North, 4d. to 4½d. Carbolic acid, 60's, 2s. 9d. to 2s. 10d. Naphthalene, £9 to £10. Salts, 55s. to 75s., bags included. Anthracene, "A" quality, 2½d. per minimum 40%, purely nominal; "B" quality, unsalable.

* All prices for pitch are now quoted on the basis of f.o.b. In order to arrive at the f.a.s. value at any port it will be necessary to deduct the loading costs and the tolls whatever they may be.

Tar Products in Scotland.

GLASGOW, *June* 17.

Distillers are maintaining quotations at previous levels and throughput continues fairly satisfactory.

Crude gas-works tar.—Actual value remains at 42s. 6d. to 47s. 6d. per ton *ex* works.

Pitch.—Export value is unchanged at about 75s. to 77s. 6d. per ton f.o.b. Glasgow, and in the home market 75s. per ton *ex* works in bulk continues to be quoted.

Refined tar to Ministry of Transport Specification is well maintained at 3¼d. to 3⅜d. per gallon f.o.r. naked, according to quantity.

Creosote oil.—There is no change in the position. B.E.S.A. Specification is 2¼d. to 2⅜d. per gallon; low gravity, 2d. to 2¼d. per gallon; and neutral oil, 2¼d. to 2⅜d. per gallon—all in buyers' rail tanks *ex* works.

Cresylic acid is now being held firmer, but actual business is still scarce. Pale, 97/99%, is 10d. to 11d. per gallon; dark, 97/99%, 9d. to 10d. per gallon; and pale, 99/100%, 1s. 1d. to 1s. 2d. per gallon—all f.o.r. in buyers' packages.

Crude naphtha commands 4d. to 4¼d. per gallon *ex* works in bulk, according to quality.

Solvent naphtha.—Available supplies are small with prices firm. 90/160 grade is 1s. 3d. to 1s. 4d. per gallon; and 90/190 grade 11d. to 1s. per gallon *ex* works.

Motor benzole is only available in small quantities at about 1s. 4d. per gallon *ex* works.

Pyridines.—90/160 grade is 3s. to 3s. 3d. per gallon, and 90/140 grade 3s. 3d. to 3s. 6d. per gallon.

Benzole Prices.

These are considered to be the market prices for benzole at the present time:

	s. d.		s. d.	
Crude benzole	0 9	to	0 9½	per gallon at works
Motor ,,	1 4	,,	1 4½	,, ,, ,,
Pure ,,	1 7½	,,	1 8	,, ,, ,,

Contracts Advertised To-Day.

Coal.

Cowes Urban District Council. [p. 878.]

Evesham Gas Department. [p. 878.]

Oxide of Iron.

Salford Corporation. [p. 878.]

Trade Notes.

"Simplex" Water Gas Plant for Huntly.

The Huntly Gas Company, Ltd., have placed an order with the Vertical Gas Retort Syndicate, Ltd., of 17, Victoria Street, Westminster, S.W. 1, for an improved type "Simplex" water gas plant.

Horseley Bridge and Engineering Company, Ltd.

The Registered and Administration Offices of this Company have been moved from 85, Lionel Street, Birmingham, to Horseley Works, Tipton, Staffs.

New Capital Issues.

Godalming Gas and Coke Company, Ltd.—For the 3160 £5 5% preference shares which Messrs. A. & W. Richards offered on behalf of the Directors of this Company, tenders were sent in for 12,250 shares at prices ranging from £6 2s. 6d. per share down to the minimum of par. The average price obtained was £5 9s. 7d. per share.

Gas Acts (1920 and 1929) Orders.

SPECIAL ORDERS.

Cheltenham and District Gas Company.

To authorize the Company to purchase the undertaking of the Pershore and District Gas and Lighting Company, Ltd., and for other purposes.

Municipal Undertakings, 1932-33.

Chorley.

A profitable year of trading, despite depressed conditions, was reported at a recent meeting of the Chorley Town Council by Alderman T. Heald, Chairman of the Gas Committee. The gross profit was £12,904, against £13,463 the year previously. There was a net balance for distribution of £3371, against £3797. The customary contribution to depreciation or reserve of £1847 had been made, and the balance had been used to defray capital expenditure on gas mains, meters, &c., also a contribution of £600 to re-modelling the heating installation at the Town Hall, and allocations to motor vehicles renewal accounts. After spending £13,203 for reserve towards re-modelling the carbonization plant, the balance in this fund remained at £17,548.

STOCK AND SHARE LIST.

Official Quotations on the London and Provincial Stock Exchanges.

Issue. £	Share.	When ex-Dividend.	Dividends. Prev. Hf. Yr. % p.a.	Dividends. Last Hf. Yr. % p.a.	NAME.	Quotations. June 17. (Provincial Exchanges June 16.)	Rise or Fall on Week.	Transactions. Lowest and Highest Prices During the Week.
1,551,868	Stk.	Apl. 3	7½	7	Alliance & Dublin Ord. ...	117–127	...	122½–124
374,000	,,	Jan. 9	4	4	Do. 4 p.c. Deb. ...	85–95	...	...
557,655	,,	Mar. 6	7	7	Barnet Ord. 7 p.c.	157–162	...	161
300,000	1	May 8	1/4½	1/9½	Bombay, Ltd.	25/–27/-	...	...
178,280	Stk.	Feb. 20	9½	9½	Bournemouth sliding scale	195–205	...	...
550,050	,,	,,	7	7	Do. 7 p.c. max. ...	157–162	...	161–161½
439,160	,,	,,	6	6	Do. 6 p.c. Pref. ...	137–142	...	140
50,000	,,	Dec. 19	3	3	Do. 3 p.c. Deb. ...	75–80	...	...
162,025	,,	,,	4	4	Do. 4 p.c. Deb. ...	101–106	...	...
210,000	,,	,,	5	5	Do. 5 p.c. Deb. ...	122–127	...	...
357,900	,,	Mar. 6	7½	7½	Brighton, &c. 6 p.c. Con. ...	152–157	...	155–156
540,000	,,	,,	6½	6½	Do. 5 p.c. Con. ...	141–146	...	143
195,500	,,	,,	6	6	Do. 6 p.c. B Pref.	134–137	...	135
1,487,500	,,	Mar. 6	5	5	Bristol 5 p.c. max.	112–114*a*	...	...
120,420	,,	Dec. 19	4	4	Do. 1st 4 p.c. Deb. ...	100½–101½*a*	...	...
217,870	,,	,,	4	4	Do. 2nd 4 p.c. Deb. ...	100½–101½*a*	...	...
328,790	,,	,,	5	5	Do. 5 p.c. Deb.	120–124*a*	...	...
855,000	,,	Apl. 3	7	8	British Ord.	147–152	...	149½
100,000	,,	Dec. 19	7	7	Do. 7 p.c. Pref.	147–152	...	...
350,000	,,	,,	—	5½	Do. 5½ p.c. Pref. ...	105–110	...	...
120,000	,,	,,	4	4	Do. 4 p.c. Red. Deb. ...	95–100	...	...
450,000	,,	,,	5	5	Do. 5 p.c. Red. Deb. ...	105–115	...	...
160,000	,,	Jan. 9	5	5	Cambridge 5 p.c. Deb. ...	117–122	...	...
100,000	10	May 22	6	4	Cape Town, Ltd.	7–8	...	...
100,000	10	Apl. 24	4½	4½	Do. 4½ p.c. Pref. ...	6–7	...	...
150,000	Stk.	Dec. 19	4½	4½	Do. 4½ p.c. Deb. ...	88–98	...	...
626,860	,,	Feb. 20	6	6	Cardiff Con. Ord.	119–124	...	...
237,860	,,	Jan. 9	2½	5	Do. 5 p.c. Red. Deb.	105–110	...	...
157,150	,,	Feb. 20	5	5½	Chester 5 p.c. Ord.	105–110*b*	...	...
98,936	1	May 22	2/-	2/-	Colombo, Ltd. Ord.... ...	25/–30/-	...	29/6
24,500	1	,,	1/4½	1/4½	Do. 7 p.c. Pref. ...	18/6–20/6	...	...
609,204	1	Mar. 20	/11'48	/11'48	Colonial Gas Assn. Ltd. Ord.	17/–19/-	...	...
296,053	1	,,	1/3'30	1/3'30	Do. 8 p.c. Pref.	20/–22/-	...	...
1,796,955	Stk.	Feb. 20	5	6½	Commercial Ord.	112–117*c*	...	114½
475,000	,,	June 12	3	3	Do. 3 p.c. Deb. ...	74–79*	–1	74
265,272	,,	Mar. 6	—	5	Do. 5 p.c. Deb. ...	120–125	...	...
807,560	,,	Feb. 20	7	7	Croydon sliding scale ...	145–150	...	148
469,590	,,	,,	5	5	Do. max. div.	101–106	...	...
500,000	,,	Jan. 9	5	5	Do. 5 p.c. Deb.	120–125	...	122½
542,270	,,	Mar. 6	7	10	Derby Con.	150–160*c*	...	...
55,000	,,	Jan. 9	4	4	Do. 4 p.c. Deb. ...	80–85*c*	...	...
209,000	,,	Mar. 6	5	5	East Hull Ord. 5 p.c.	106–111	...	...
179,500	,,	Mar. 6	6	6	East Surrey Ord. 5 p.c.	120–125	...	...
155,019	,,	Dec. 19	5	5	Do. 5 p.c. Deb. ...	117–122	...	...
1,002,180	,,	Apl. 3	16	17	European, Ltd.	128–133	...	130–130½
19,373,992	,,	Feb. 20	5½	5½	Gas Light & Coke 4 p.c. Ord.	25/–26/-*f*	...	25/7½–26/-
2,600,000	,,	,,	8½	8½	Do. 8½ p.c. max.... ...	85–88	...	85½–86
4,477,106	,,	,,	4	4	Do. 4 p.c. Con. Pref. ...	99–102	...	100–100½
6,102,497	,,	June 12	3	3	Do. 3 p.c. Con. Deb. ...	76–79*	–1	77–78½
3,642,770	,,	,,	5	5	Do. 5 p.c. Red. Deb. ...	112–115*	–2	113–114½
3,500,000	,,	,,	4½	4½	Do. 4½ p.c. Red. Deb. ...	108–111*	–3	108½–111
270,466	,,	Mar. 6	6	6	Harrogate New Cons. ...	113–118	...	...
82,500	,,	Mar. 6	7	7	Hastings & St. L. 5 p.c. Conv.	138–143	...	...
258,740	,,	,,	5½	5½	Do. 5½ p.c. Conv.	110–115	...	...
70,000	10	Apl. 24	†10	†10	Hongkong & China, Ltd. ...	14–16	...	...
218,200	Stk.	Mar. 6	6	6	Hornsey Con. 5½ p.c. ...	122–127	...	...
5,600,000	,,	May 22	10	14	Imperial Continental Cap.	202–212	–3	205½–209
223,130	,,	Feb. 6	3½	3½	Do. 3½ p.c. Red. Deb.	89–94	...	...
235,242	,,	Mar. 6	8½	8½	Lea Bridge 5 p.c. Ord. ...	170–176	...	...
2,145,907	,,	Mar. 6	6	6	Liverpool 5 p.c. Ord. ...	125½–126½*b*	...	...
245,500	,,	Dec. 19	5	5	Do. 5 p.c. Red. Pref. ...	105–115*b*	...	...
306,088	,,	Jan. 19	4	4	Do. 4 p.c. Deb. ...	101–109*b*	...	...
165,736	,,	Feb. 20	8	10	Maidstone 5 p.c. Cap. ...	180–200	...	...
56,176	,,	Dec. 19	3	3	Do. 3 p.c. Deb. ...	70–75	...	...
75,000	5	June 12	†10	†10	Malta & Mediterranean ...	9–11*	...	10½–10⅝
392,000	—	Apl. 1	5½	5½	Mesropolitan (of Melbourne) 5½ p.c. Red. Deb.	98–103	...	...
231,978	Stk.	Mar. 6	5	5	M. S. Utility "C." Cons. ...	103–108	...	...
818,657	,,	,,	4	4	Do. 4 p.c. Cons. Pref.	93–98	...	97
112,126	,,	Jan. 9	4	4	Do. 4 p.c. Deb. ...	102–104	...	...
148,955	,,	,,	5	5	Do. 5 p.c. Deb. ...	115–120	...	...
675,000	,,	21 May '31	†6	†6	Montevideo, Ltd.	50–60	...	58
2,061,315	,,	Mar. 6	5	5½	Newcastle & Gateshead Con.	24/6–25/6*d*	...	...
682,856	,,	,,	4	4	Do. 4 p.c. Pref. ...	99–101*d*	–½	...
776,706	,,	Jan. 9	3½	3½	Do. 3½ p.c. Deb. ...	91–93*d*	...	...
277,285	,,	May 8	5	5	Do. 5 p.c. Deb. '48...	107–109*d*	...	...
274,000	,,	Feb. 20	5	5	Newport (Mon.) 5 p.c. max.	101–103*a*	+1	...
204,940	,,	Mar. 20	7½	7½	North Middlesex 5 p.c. Con.	137–143	+3	...
396,160	,,	Feb. 6	5	5	Northampton 5 p.c. max. ...	103–108	...	...
300,000	,,	Apl. 24	9	7	Oriental, Ltd.	114–119	...	...
316,617	,,	Dec. 19	8	8	Plym'th & Stonehouse 5 p.c.	157–167	...	...
504,416	,,	Feb. 20	8	8	Portsm'th Con.Stk. 4 p.c.Std.	161–166	...	163½–165
241,446	,,	,,	5	5	Do. 5 p.c. max. ...	104–109	...	...
114,000	,,	Feb. 20	5	5	Preston 5 p.c. Pref.	103–108	...	...
686,312	,,	Jan. 23	4	4	Primitiva 4 p.c. Rd. Db. 1911	80–85	...	...
389,813	,,	Dec. 19	4	4	Do. 4 p.c. Cons. Deb.	80–85	...	89½
150,000	10	Mar. 20	6	6	San Paulo 6 p.c. Pref. ...	6⅞–7⅛	...	...
1,736,968	Stk.	Sept. 5	6	6	Sheffield Cons.	123–127*e*	...	...
95,000	,,	Jan. 9	4	4	Do. 4 p.c. Deb.	91–95*e*	...	...
133,201	,,	Feb. 20	8½	5	Shrewsbury 5 p.c. Ord. ...	125–130	...	...
90,000	10	June 12	15	14	South African	3–5*	...	...
6,709,895	Stk.	Feb. 20	5	7	South Met. Ord.	123–127	–1	124½–126
1,135,812	,,	,,	6	6	Do. 6 p.c. Irred. Pf.	136–141	...	136–138½
850,000	,,	,,	—	20/-*g*	Do. 4 p.c. Irred. Pf.	99–103	...	100½–101½
1,895,445	,,	Jan. 9	3	3	Do. 3 p.c. Deb. ...	77–80	...	79
1 000,000	,,	Jan. 23	5	5	Do. 5 p.c. Red. Deb.	112–116	–1½	113–115½
209,820	,,	Mar. 6	8½	8½	South Shields Con.	147½–152½*d*	...	...
1,543,795	,,	Feb. 20	6	6	South Suburban Ord. 5 p.c.	124–129	...	126–127½
300,000	,,	,,	5	5	Do. 5 p.c. Pref.	113–118	...	...
868,837	,,	Dec. 19	5	5	Do. 5 p.c. Deb.	120–125	...	123½
647,740	,,	Feb. 20	5	5	Southampt'n Ord. 5 p.c. max.	107–112	...	...
121,275	,,	Dec. 19	4	4	Do. 4 p.c. Deb.	100–105	...	...
350,000	,,	Mar. 6	9/-	5½	Swansea 5½ p.c. Red. Pref.	108–112	...	...
200,000	,,	Dec. 19	6½	6½	Do. 6½ p.c. Red. Deb.	108–110	...	...
1,076,490	,,	Mar. 6	6½	6½	Tottenham and District Ord.	142–147	...	142–144½
300,000	,,	,,	5½	5½	Do. 5½ p.c. Pref. ...	123–128	...	...
62,235	,,	,,	5	5	Do. 5 p.c. Pref. ...	110–115	...	...
199,005	,,	June 12	4	4	Do. 4 p.c. Deb. ...	96–101*	–2	99
85,701	,,	Apl. 3	6	6	Tuscan, Ltd., 6 p.c. Red. Db.	80–85	...	...
347,769	,,	Mar. 6	7	7	Uxbridge, &c., 5 p.c. ...	140–145	...	142
88,330	,,	,,	5	5	Do. 5 p.c. Pref. ...	110–115	...	110
1,322,220	,,	Mar. 6	7	7	Wandsworth Consolidated	145–150	...	146–148
1,096,373	,,	,,	5	5	Do. 5 p.c. Pref.	112–117	...	114–114½
1,317,964	,,	Dec. 19	5	5	Do. 5 p.c. Deb.	120–125	...	122½–124
158,400	,,	Mar. 6	5	6A	Winchester W.& G.5p.c.Con.	109–114	...	...

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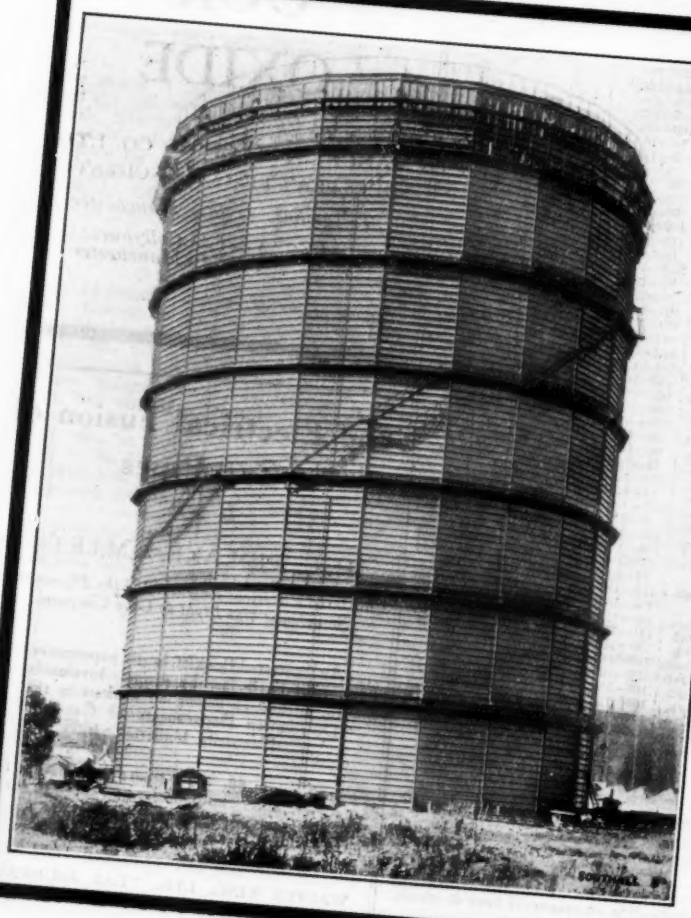

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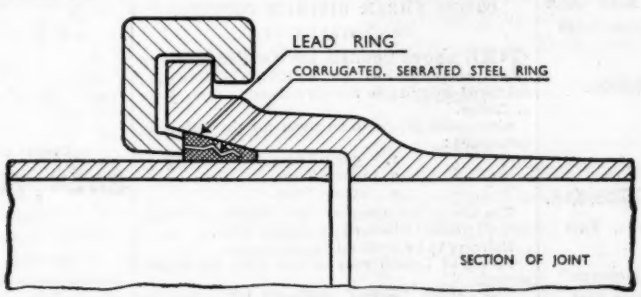

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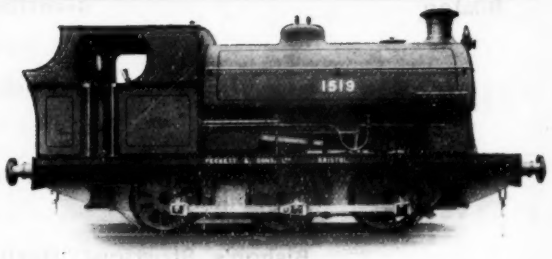

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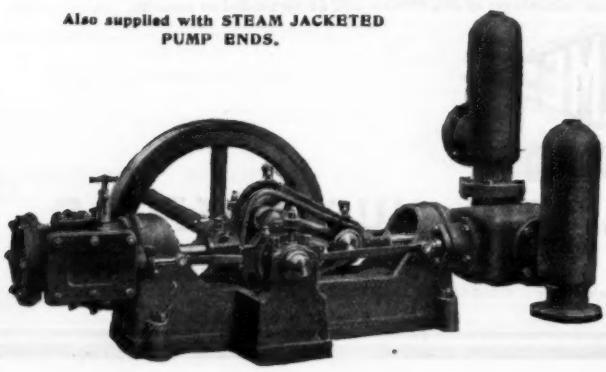

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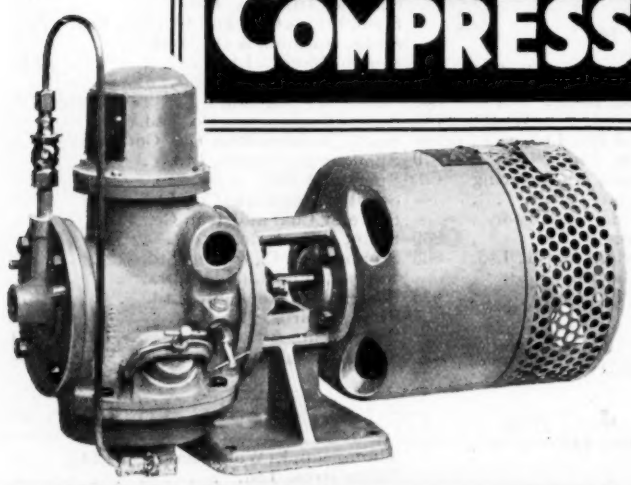

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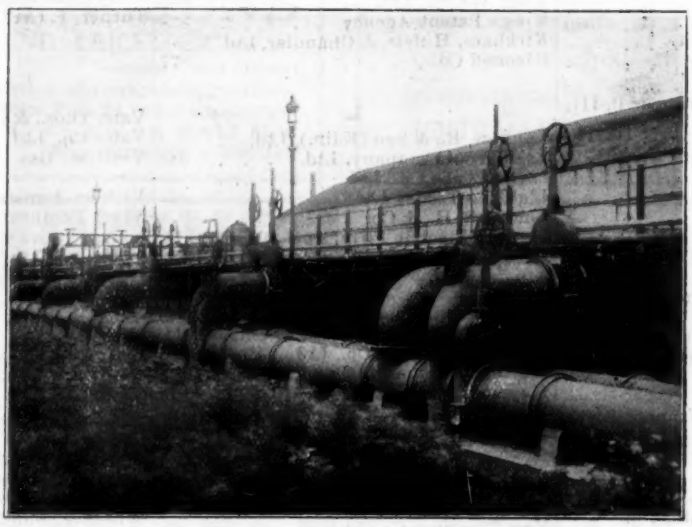

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